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Figura de la portada: *Rhyssoplax olivacea* (Spengler, 1797). Fotografia de Miquel Pontes.

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Biodiversity in anthropized marinas
The case of the Barcelona Forum bathing area (Spain)

Miquel Pontes**, Xavier Salvador****, Àlex Parera*, **, Guillermo Álvarez***
& Manuel Ballesteros*, **

* Departament Biologia Evolutiva, Ecologia i Ciències Ambientals. Universitat de Barcelona. Avda. Diagonal, 643. 08028 Barcelona, Spain.
** Grup d'Estudis VIMAR (Vida Marina). Rocafort, 246. 08029 Barcelona, Spain.
*** Federació Catalana d'Activitats Subaquàtiques (FECDAS). Moll de la Vela, 1. 08930 Sant Adrià de Besòs, Barcelona, Spain.
**** Institut de Ciències del Mar (ICM-CSIC). Passeig Marítim de la Barceloneta, 37. 08003 Barcelona, Spain)

Corresponding author: Miquel Pontes. A/e: *miquelpontes@gmail.com*

Abstract

The Mediterranean Sea is a hotspot for biodiversity and endemic species (between 4 % and 18 % of known species are endemic, depending on the group), but this environment, favourable for native species, also favours exotic species. To ascertain how biodiversity has been impacted by intense human activity, we surveyed the marine life in the Barcelona Forum bathing area, an artificial beach receiving large amounts of waste from neighbouring areas and effluent from the nearby sewage treatment plant. Despite such eutrophic influences and the replacement of natural substrates with artificial ones, a surprisingly rich marine biota of 514 species was found. The groups with most species identified were molluscs (176), fish (88), crustaceans (65) and algae (50). These results include 15 exotic species that have settled in this ecosystem, such as the sea hare *Bursatella leachii* and the polychaete *Branchiomma luctuosum*, and some iconic natives such as the Fan mussel (*Pinna nobilis*) and the Dusky grouper (*Epinephelus marginatus*). Urban litter was sampled and no significant deleterious effects on the biota were detected. The site acts as a refuge for fish and is conducive to the settlement of encrusting species that colonize new substrates.

Key words: Marinas**,** Biodiversity, alien species, marine litter, Barcelona Forum

Resum

Biodiversitat en marines antropitzades. El cas de la zona de banys del Fòrum de Barcelona (Espanya)

El mar Mediterrani és un punt calent per a la biodiversitat i les espècies endèmiques (entre el 4 % i el 18 % de les espècies conegudes són endèmiques, segons el grup), però aquest entorn, favorable per a les espècies autòctones, també afavoreix les espècies exòtiques. Per esbrinar com la biodiversitat s'ha vist afectada per la intensa activitat humana vàrem examinar la vida marina de la zona de bany del Fòrum de Barcelona, una platja artificial que rep gran quantitat de residus de zones veïnes i efluents de la depuradora propera. Malgrat aquestes influències eutròfiques i la substitució dels substrats naturals per artificials, es va trobar una biota marina sorprenentment rica, amb 514 espècies. Els grups amb més espècies identificades van ser els mol·luscs (176), els peixos (88), els crustacis (65) i les algues (50). Aquests resultats inclouen 15 espècies exòtiques que s'han assentat en aquest ecosistema, com la llebre marina *Bursatella leachii* i el poliquet *Branchiomma*

luctuosum, i algunes espècies nadiues emblemàtiques com la nacra (*Pinna nobilis*) i el mero (*Epinephelus marginatus*). Es van obtenir mostres de residus urbans i no es van detectar efectes nocius significatius sobre la biota. El lloc actua com a refugi de peixos i propicia l'assentament d'espècies incrustants que solen colonitzar nous substrats.

Paraules clau: Marines, Biodiversitat, espècies exòtiques, residus marins, Fòrum de Barcelona

Introduction

There is a great lack of knowledge regarding the marine environment compared to the terrestrial environment. Concern over degradation of the marine environment in recent decades has prompted a worldwide increase in the number of marine biodiversity studies. In the Mediterranean Sea, these include Bianchi & Morri (2000) and Boudouresque (2004) with estimates of the current biodiversity and distribution patterns, and Lloret *et al*. (2008) who showed that these changes over time are related to anthropogenic impacts.

As more than 12,000 species of macroscopic organisms are known in the Mediterranean Sea, it is considered a "hot spot" of marine biodiversity (Coll *et al*., 2010). It contains about 4 % to 18 % of all living marine species despite representing only 0.8 % of the Earth's ocean surface (Bianchi & Morri, 2000). Recently, over 600 alien species of macroscopic marine organisms have been recorded (Zenetos *et al*., 2008). Experiments have shown that seawater quality degradation facilitates the presence of non-native species (Crooks *et al*., 2011). The potential of recreational boats to act as vectors for introducing alien species has been suggested by Davidson *et al*. (2010).

In recent decades, Mediterranean marine biodiversity has been profoundly altered by the joint action of climate change, including increased sea water temperature and acidification and, especially, direct human impacts such as eutrophication, development of coastal areas, professional fishing and the incidental introduction of alien species on international shipping (Coll *et al*., 2010).

The coasts and sea fronts of many coastal cities have been substantially modified for decades by the extraordinary increase in the human population living on or near the coast. To satisfy the demands of commercial, tourist and social activities, new ports and marinas have been built, breakwaters of the main ports lengthened, artificial reefs and submerged rock barriers built to protect the beaches, and the seabed dredged for sand to regenerate beaches after big storms. These developments, combined with the loss of natural habitats, have caused substantial changes in the biota that inhabit the seabed (Airoldi *et al*., 2009). Bulleri & Chapman (2010) have summarized the main effects produced by the introduction of artificial coastal structures, both in biotic factors (marine communities and their composition) and abiotic factors (nutrients, water temperature, new habitats) and consider these changes as possibly irreversible, stating the need for management of anthropogenic disturbances and to incorporate ecological criteria into coastal engineering to preserve biodiversity. Firth *et al*. (2016) discuss the «ocean sprawl» (increasing human anthropization of the marine environment) and point to the need for managing this phenomenon in a way compatible with strengthening the resilience of ecosystems. Bugnot *et al*. (2021) provide a global assessment of the extent of existing and projected marine construction and its effects on the seascape, while setting a baseline for tracking future marine human development.

In a multi-year study conducted in various Singapore marinas, Chou *et al*. (2015) studied the evolution of the communities of epibiont marine organisms that settle on pylons, pontoons, walls of breakwaters (seawalls) and on the muddy bottom, and have verified that these new surfaces can support a varied and abundant fauna of epibionts and create new habitats for fauna and flora, a fact also verified by Connell (2000). It has also been proven that the increase in artificial substrates in the superficial marine environment can favour the settlement of exotic species more than native ones

(Tyrrel & Byers, 2007; Mineur *et al*., 2012). Other authors (Deudero & Alomar, 2015, Crocetta *et al*., 2020) have studied the effects that the accumulation of marine litter can produce on the different species, while Rech *et al*. (2016) studied how this litter can be the vector for the introduction of alien species. Mayer-Pinto *et al*. (2015) studied the anthropogenic effects on biodiversity and ecosystem function in Sydney Bay (Australia), one of the most studied bays and a biodiversity hot spot, and concluded that there are many gaps in the knowledge of the effects of anthropic stressors on the ecosystem that must be addressed and translated into coherent environmental plans. Guerra-García *et al*. (2021) studied eight marinas in southern Spain and developed an integrative assessment method to determine their ecological status. Other authors (Megina *et al*., 2016) have used bioindicators to analyse the settlement of autochthonous and alien fouling organisms on pontoons and breakwater walls in marinas and bays frequented by commercial vessels. They concluded that there is a barrier to the spread of exotic species between harbours and natural rocky habitats, while floating pontoons seem to be a key element in marine biological invasions.

Airoldi & Bulleri (2011) have verified that the lack of maintenance and control of submerged artificial urban structures (floating pontoons, breakwaters, port pylons, etc.) facilitates the arrival and settlement of opportunistic species and favours alien and invasive species, increasingly common due to the high volume of maritime traffic. This has been also verified by Ferrario *et al*. (2017) when studying and comparing the fouling communities of five nearby bays and marinas in western Mediterranean waters. Carlton & Ruiz (2016) carried out a review of the anthropogenic vectors involved in the arrival of non-native species in the marine and estuarine environment focussing on the quantification methods, while Vaz-Pinto *et al*. (2014) specifically dealt with the different propagation vectors and invasiveness of algal species and exposed some remarkable European invasion case studies. Murray *et al*. (2011) considered recreational boats as a high-risk vector for the primary introduction of alien species and their subsequent settlement, also indicating the need for regulation to avoid it. An exhaustive list of non-native species observed in 34 marinas throughout the Mediterranean has been compiled by Ulman *et al*. (2017), accounting for a total of 76 alloctonous species belonging to the taxonomic groups of Ascidiacea, Bryozoa, Crustacea, Mollusca, Polychaeta, Porifera and Pycnogonida. Ros *et al*. (2013) analysed the role of marinas and recreational boats for the presence of alien species of certain taxonomic groups such as the amphipods of the family Caprellidae on the island of Mallorca. It has also been shown that so-called citizen science can contribute to the knowledge of the presence of non-indigenous species (Tanduo *et al*., 2020). There are few studies that have focussed on the analysis of the environmental and ecological changes and consequences of the construction of recreational marinas. In this regard, Rivero *et al*. (2013), comparing the biodiversity and some environmental parameters in the interior and exterior of a marina in SE Australia, found that within the marinas there are important changes in the fouling community, easier larval recruitment, reduced flow of water, more suspended particles and higher concentrations of copper and lead.

The urban coastal area located north of the port of Barcelona has undergone important changes since the late 1980's. Up until that time, the urban coast north of Barcelona consisted of neglected beaches separated from the city by railways and industrial facilities. In preparation for the 1992 Barcelona Olympic Games, the area was developed with leisure facilities and the quality of the seawater and the beaches was improved, bringing it closer to the city through public transport. The celebration of the 2004 Universal Forum of Cultures engaged the remodelling of the northern coastal area of Barcelona with the construction of the Port Forum, and the adjacent bathing area where the present study was conducted. This area is accessible to the public and allows for swimming and simple nautical activities, given its easy access by stairs and ladders for entry into the water. This bathing area forms a small, semi-enclosed, marine habitat which, despite accumulations of construction waste materials and urban litter, has acquired a wide range of species of algae, invertebrates and fish, both indigenous and alien.

Aim of this study

To record the biodiversity of a small, strongly anthropized marine habitat.

Main objectives

1– To carry out a census of marine biodiversity in the Barcelona Forum bathing area.
2– To produce a photographic record of all species.
3– To record the presence of non-native species and their adaptation to the study area.

Material and methods

Study area

The Barcelona Forum bathing area (41°24'35.8"N, 2°13'37.6"E) is a semi-enclosed, artificial, marine area located to the north of Barcelona. It is limited at the northern end by the Port Forum marina and to the south by the breakwater of the drainage channel of the Besós wastewater treatment plant (Fig. 1). The area, measuring approximately 375 × 30 m, is sheltered from the open sea by a breakwater of concrete blocks. It is connected to the sea at the northern end by a mouth that allows the entry of small recreational boats, and by several narrow openings in the breakwater at the southern end that allow some water circulation. The area is divided longitudinally into an inner and outer zone by a row of concrete pylons and concrete walls. The inner zone is less than 2 m in depth and its bed is a concrete platform covered with coarse sand, construction rubble and small, scattered, loose stones. The outer zone descends to about 5-6 m with a bed of large, stone blocks resting on silt.

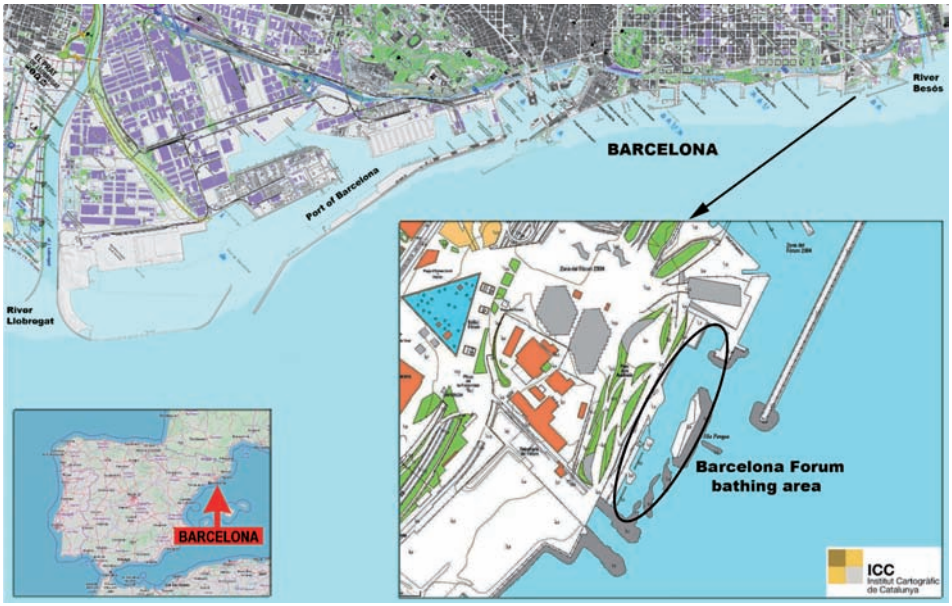

Figure 1. Map of the Barcelona Forum bathing area.

Mean water temperature varies from 13 ºC in January and February to 23-25 ºC in July and August. Underwater visibility is generally poor, with an average 3 meters and maximum 5 meters, falling to zero after heavy rain causes overflow of sewage effluent from the nearby wastewater treatment plant.

Sampling was assisted by the facilities of Federació Catalana d´Activitats Subaquàtiques (FECDAS) and the Saita Diving club, which are located nearby.

Transects

The study area was divided into three transects with defined starting points as indicated in Fig 2.

Transect 1: A circular route around the large concrete platform covered with coarse sand, along the large blocks outside of the pylons, where most fishes live, and back along the access stairs, which is home to a great amount of small creatures.

Transect 2: A route along the large rocks in the middle of the area, reaching the small bay formed by the two piers, which has the lowest hydrodynamism of the area and a sandy bottom with very interesting fauna.

Transect 3: A circular route at the southernmost part of the Forum bathing area, along the walls and the large blocks separating the area from the open sea, and back to the entry point. Due to the partially open layout of the large concrete blocks, there is a higher hydrodynamism and generally worse visibility than in the other transects.

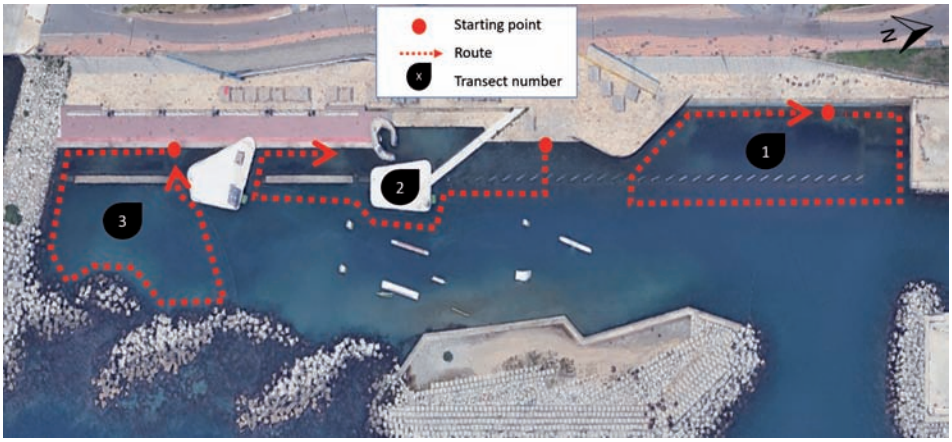

Figure 2. Regular qualitative sampling transects in the area of study

Sampling

Sampling, over a total of 134 diver hours, was carried out by researchers from the University of Barcelona in close collaboration with the citizen science group VIMAR (Vida Marina) and FECDAS.

Several sampling approaches were used:

From October 2018 to September 2019, eleven regular, monthly, qualitative visual samplings were conducted with breath-hold and/or SCUBA diving in daytime hours. Samplers were organized in groups of 2-3 divers for safety, and every group had at least one diver with an underwater camera. Dive durations were limited to 60 minutes to harmonize sampling effort. One of the sampling groups used a GPS tracker to assess marine fauna and litter distribution. Total sampling effort for this sampling approach was 53 diver hours.

From May 2018 to July 2019, nine non-periodical, qualitative visual samplings were conducted by two SCUBA divers during daytime, following the same routes of the regular samplings. Total sampling effort for this sampling approach was 27 diver hours.

From 2017 to July 2019, a total of 14 non-periodical, qualitative visual samplings were conducted at night with breath-hold and/or SCUBA diving, performing a circular route around the whole bathing area, following the walls and artificial structures and focusing on benthic species. Total sampling effort for this sampling approach was 42 diver hours.

A total of four periodical quantitative samplings were conducted during daytime with SCUBA diving, both along the bathing area walls and pylons, by a separate team of two divers who took samples of algae and scrapings from the walls and pylons for a laboratory study of microfauna. Total sampling effort for this sampling approach was 12 diver hours.

During all samplings, numerous photographs of all observed species were taken to perform later analyses of the pictures for positive identification of the animals and seaweeds. Some additional data were recorded by handwriting on a PVC slate, such as animal size, substrate, depth, mating behaviour, and presence of spawn. Occasionally, when a species could not be determined visually, samples were collected by divers with the corresponding collection permits, and processed and photographed in the laboratory to achieve a positive identification.

Urban litter qualitative sampling was also conducted to assess how different types of marine litter concentrated in certain areas impact the local biodiversity.

Species identification

Most of the survey species were identified from in situ photographs; a few were photographed in the laboratory for identification, particularly those from wall and pylon scrapings. For certain difficult-to-identify species of sponges, crustaceans, echinoderms and tunicates, the appropriate taxonomic guides (Rield, 1986; Corbera *et al*., 1996; Martín, 1999; Pla, 2000; Hofrichter, 2005; Louisy, 2006; Scaperrotta *et al*., 2014; Rodríguez *et al*., 2013; Trainito & Baldacconi, 2014; Ballesteros & Llobet, 2015; Ballesteros *et al*., 2019; Salvador, 2019 and Alf *et al*., 2020) were used. Tentative species identifications are indicated with «cf.» and in other cases the genus or higher taxon with a sequential numbering are used. For the current taxonomy, we follow the World Register of Marine Species (WoRMS) and other recent articles cited as appropriate.

Equipment

The digital cameras used with appropriate underwater housings and external lighting systems were Nikon D90, D7200 and D7500 with 60mm Nikon macro lenses, Sony a6300 with 16/50 lens and external macro +2 wet lens and Olympus E-PM1, TG4 and TG5. All are capable of providing high resolution digital images.

Picture geolocation was made with a Holux M-1000C GPS tracker in a waterproof housing attached to the diver by a bungee line so it followed them and recorded their location every 3 seconds. By synchronizing the digital camera clock with the GPS tracker it was possible to establish the exact location of every photograph of biota and litter. These location coordinates were then recorded in the proper EXIF header fields of each picture file and plotted on local maps using the software BT747 v2.1.3 by Mario De Weerd (accessible at https://www.bt747.org/).

Results

Habitats

Within the area of study, we found six well-differentiated habitats (Fig 4):

1) The concrete walls of the bathing area are characterized by large vertical surfaces that allow the settlement and development of both sessile and mobile organisms, mainly sponges, cnidarians,

Figure 3. GPS tracking route for transects 1 (red) and 2 (green).

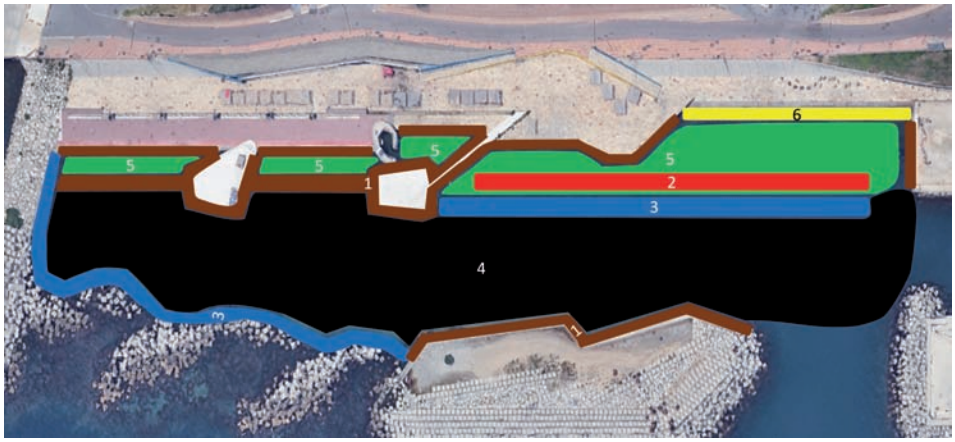

Figure 4. Habitats found in the Barcelona Forum bathing area: 1) Concrete walls; 2) Concrete pylons; 3) Big rocks area; 4) Silty bottom; 5) Flat concrete plain with sand; 6) Access stairs.

and gastropods that withstand variable hydrodynamics, unlike the generally low impact water movement in other parts of the site. Occasional crevices serve as a refuge for some fish and crustaceans.

2) The pylons located in the middle of the area have surfaces that are too small for the development of large organisms but ideal for smaller ones. The bases of the pylons have many cavities used for nesting and concealment. Some of these pylons are under high hydrodynamic impact so the communities inhabiting them must be able to cope with these conditions.

3) The large rock area, located outside of the pylons, has many holes and crevices, ideal for sciophilous species like red algae and fauna that require a hole to nest or for refuge, such as crabs, sea urchins, gobies, scorpion fish, and a large number of infralapidicolar species.

4) The silty bottom outside of the block area. Its colour reveals an anoxic environment, and thus is mostly devoid of life, but is home to some sand-dwelling species, like the conger eel, and an occasional sea cucumber.
5) The flat concrete platform, partly covered with coarse sand and small stones, is home to some polychaetes and algae, is a hunting territory for schools of small fishes, and a place where most human litter, mainly rolls of wet wipes, accumulates.
6) The access stairs have 100 meter long vertical risers and horizontal tread surfaces, with small crevices in the lower part of every riser full of small marine life, predominantly cnidarians, sea urchins, fish and crustaceans. They are occasionally subject to strong water movement and to periodic drops in sea level, locally known as «minves», which expose marine life to the air and sun for days, killing those unable to move.

General Biodiversity

In the Forum bathing area, 514 macroscopic species have been recorded in the following groups: Ciliophora (1), Algae (50), Porifera (27), Cnidaria (21), Acoelomorpha (1), Platyhelminthes (10), Nemertea (3), Sipuncula (2), Polychaeta (25), Mollusca (176: Polyplacophora 6, Bivalvia 42, Gastropoda 123 and Cephalopoda 5), Phoronida (1), Bryozoa (9), Crustacea (65), Echinodermata (14), Tunicata (18), Pisces (88) and Aves (3). Each taxonomic group is discussed below with an alphabetical list of species and observation details.

Codes for Observers (alphabetically by surname)

GA: Guillermo Álvarez; MB: Manuel Ballesteros; EC: Eugeni Canals; OC: Oriol Cortés; CE: Carlota Escarré; SF: Sara Fuertes; CG: Carles Galià; RG: Román Gómez; CP: Creu Palacín; AP: Àlex Parera; MPE: Marc Peralta; MP: Miquel Pontes; XS: Xavier Salvador; MT: Mario Tirador

Results by taxonomic groups

Ciliophora (Fig 5a)

This group includes unicellular species difficult to see without a microscope. The only species that we could positively record in the Forum bathing area is the giant ciliate *Zoothamnium niveum*, forming macroscopic colonies up to 15 mm in length, covered with a symbiotic, sulphur-oxidizing bacteria that gives them their characteristic whitish colouration.

Table 1. Ciliophora species and observations (dd/mm/yyyy).

Ciliophora (1)	**Observations**
Zoothamnium niveum Ehrenberg, 1838	XS (06/08/2020)

Algae (Figs. 5b-h; 6a-b)

Algae are a group often difficult to identify as some are only distinguishable with a microscope. A total of 50 species were identified of which 14 were Chlorophyta, 27 were Rhodophyta and 9 were Ochrophyta (Table 2).

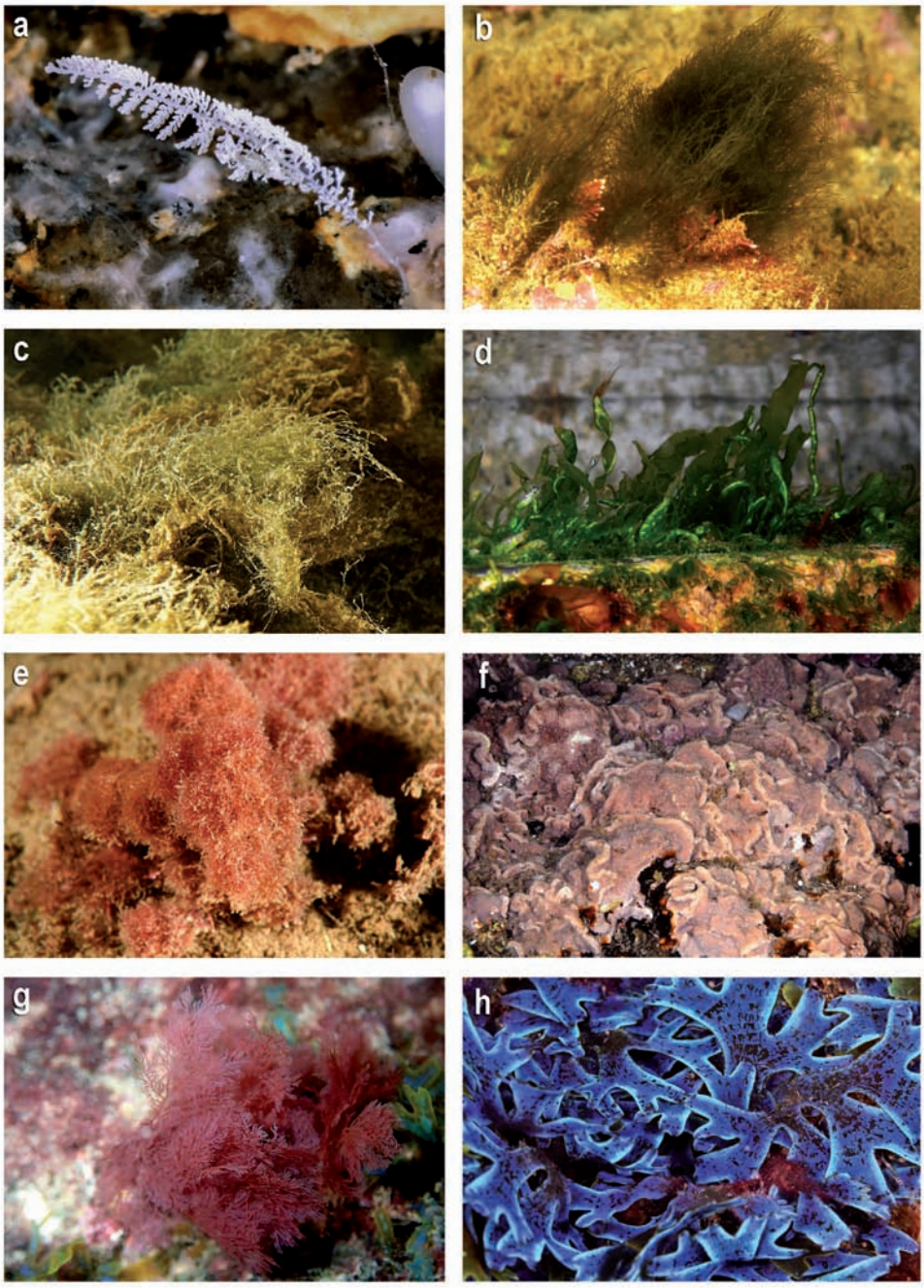

Figure 5. CILIOPHORA. a) *Zoothamnium niveum*; ALGAE. b) *Cladophora* sp.; c) *Derbessia tenuissima*; d) *Ulva intestinalis*; e) *Asparagopsis armata* (sporophyte); f) *Lithophyllum incrustans*; g) *Plocamium* sp.; h) *Dictyota cyanoloma*. Pictures: X. Salvador (a, d, f, h); M. Pontes (b, c, e); A. Parera (g).

Most of the study area sea bottom is characterised by the presence of encrusting calcareous algae. The dominant species is *Lithophyllum incrustans* Philippi, 1837. An algal bloom occurs at the end of winter when species of the genus *Dictyota* and *Cladophora* predominate in the photophyllic areas. There is a predominance of rhodophyte species in the sciophilous conditions at the base of concrete blocks where the water is generally turbid.

The establishment of the alien *Dictyota cyanoloma* (Ochrophyta) and *Asparagopsis armata* (Rhodophyta) in the bathing area is probably favoured by the higher temperature and the morphology of this particular ecosystem. There are possible indications of other cryptic invasive species that need further morphological and genetic analysis for identification. The local conditions favour the growth of highly adaptive species such as the native *Padina pavonica* (Linnaeus) Thivy, 1960 (see Celis-Plá *et al*., 2015) and the Australian alien *Dictyota cyanoloma* Tronholm *et al*., 2010, (Steen *et al*. 2017).

Asparagopsis armata Harvey, 1855 was identified from its sporophyte previously known as *Falkenbergia rufolanosa* (Harvey) F. Schmitz, 1897. The gametophyte formerly known as *Halicystis parvula* (F. Schmitz ex Murray, 1893) enabled the detection of *Derbesia tenuissima* (Moris & De Notaris) P. Crouan & H. Crouan, 1867. *Ulva intestinalis* Linnaeus, 1753, which is an effective bioindicator of heavy metal pollution (Rodríguez-Castañeda *et al*., 2006), was also found in the study area.

Table 2. Algae species and observations (dd/mm/yyyy).

Chlorophyta (14)	**Observations**
Bryopsis duplex De Notaris, 1844	AP (21/08/2018; 22/12/2018; 27/02/2019); MP (06/04/2019); XS (23/11/2017; 25/11/2017; 05/12/2017; 03/02/2018; 20/11/2019; 06/08/2020; 19/11/2020).
Bryopsis plumosa (Hudson) C.Agardh, 1823	MP (11/05/2019).
Bryopsis sp. J.V.Lamouroux, 1809	XS (25/11/2017; 23/12/2017).
Cladophora sp.1 Kützing, 1843	AP (22/12/2018; 21/08/2018); MP (24/11/2018; 22/12/2018); XS (23/11/2017; 25/11/2017; 23/12/2017; 20/11/2019; 06/08/2020; 19/11/2020).
Cladophora sp.2 Kützing, 1843	AP (21/08/2018); MP (09/02/2019); XS (23/11/2017; 05/12/2017; 03/02/2018).
Codium coralloides (Kützing) P.C.Silva, 1960	XS (20/11/2019).
Codium effusum (Rafinesque) Delle Chiaje, 1829	XS (27/04/2018; 20/11/2019).
Codium vermilara (Olivi) Delle Chiaje, 1829	MP (28/09/2019); XS (20/11/2019).
Derbesia tenuissima (Moris & De Notaris) P.Crouan & H.Crouan, 1867	AP (26/01/2019; 02/04/2019; 10/04/2019; 11/05/2019; 13/07/2019); MP (22/12/2018); XS (27/04/2018); MT (02/03/2019).
Halimeda tuna (J.Ellis & Solander) J.V.Lamouroux, 1816	XS (27/04/2018).
Ulva compressa Linnaeus, 1753	AF (09/02/2019); XS (27/04/2018; 20/11/2019).
Ulva intestinalis Linnaeus, 1753	XS (27/04/2018).
Ulva rigida C.Agardh, 1823	AF (09/02/2019); AP (22/12/2018); MP (11/07/2020); XS (23/11/2017; 25/11/2017; 27/04/2018; 06/08/2020).
Valonia macrophysa Kützing, 1843	AP (20/09/2018); MP (11/07/2020).
Rhodophyta (27)	**Observations**
Alsidium corallinum C.Agardh, 1827	MP (26/01/2019).
Amphiroa beauvoisii J.V.Lamouroux, 1816	AF (09/02/2019); AP (22/12/2018; 02/04/2019; 13/05/2019; 13/07/2019); MP (24/11/2018; 09/02/2019).

Amphiroa cryptarthrodia Zanardini, 1843	XS (27/04/2018).
Amphiroa rigida J.V.Lamouroux, 1816	XS (27/04/2018; 19/11/2020).
Amphiroa rubra (Philippi) Woelkerling, 1983	XS (25/11/2017; 23/12/2017).
Antithamnion cruciatum (C.Agardh) Nägeli, 1847	XS (27/04/2018; 20/11/2019).
Asparagopsis armata Harvey, 1855	AF (09/02/2019); SF (26/01/2019); AP (22/12/2018; 26/01/2019; 13/07/2019); MP (24/11/2018; 22/12/2018).
Bornetia secundiflora (J.Agardh) Thuret, 1855	XS (25/11/2017; 05/12/2017; 03/02/2018).
Ceramium sp. Roth, 1797	AP (22/12/2018; 27/02/2019); MP (22/12/2018; 09/02/2019).
Dasya sp. C.Agardh, 1824	XS (27/04/2018).
Dermocorynus dichotomus (J.Agardh) Gargiulo, M.Morabito & Manghisi, 2013	MP (22/12/2018).
Ellisolandia elongata (J.Ellis & Solander) K.R.Hind & G.W.Saunders, 2013	AF (09/02/2019); AP (21/08/2018; 22/12/2018; 26/01/2019; 27/02/2019; 02/04/2019; 13/07/2019); MP (24/11/2018; 22/12/2018; 09/02/2019; 06/04/2019); XS (23/11/2017; 25/11/2017; 27/04/2018; 18/05/2018; 20/11/2019; 19/11/2020); MT (09/02/2019).
Gastroclonium clavatum (Roth) Ardissone, 1883	AP (02/04/2019; 10/04/2019).
Herposiphonia tenella (C.Agardh) Ambronn, 1880	AP (26/01/2019).
Hildenbrandia crouaniorum J.Agardh, 1851	AF (09/02/2019); AP (24/10/2018; 26/01/2019; 15/06/2019; 13/07/2019; 24/07/2019); MP (24/11/2018; 22/12/2018); XS (25/11/2017; 05/12/2017; 27/04/2018; 06/08/2020; 16/09/2020).
Lithophyllum incrustans Philippi, 1837	CE (11/05/2019); AF (09/02/2019); SF (26/01/2019); AP (12/07/2018; 21/08/2018; 20/09/2018; 22/12/2018; 26/01/2019; 06/04/2019; 11/05/2019; 13/05/2019; 13/07/2019; 18/07/2019; 10/08/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 26/01/2019; 09/02/2019; 06/04/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (25/11/2017; 03/02/2018; 27/04/2018; 18/05/2018; 02/02/2019; 20/11/2019; 06/08/2020; 19/11/2020).
Lithophyllum papillosum (Zanardini ex Hauck) Foslie, 1900	AP (26/01/2019).
Mesophyllum expansum (Philippi) Cabioch & M.L.Mendoza, 2003	CE (13/07/2019); MP (10/08/2019; 28/09/2019).
Neogoniolithon brassica-florida (Harvey) Setchell & L.R.Mason, 1943	AP (18/07/2019).
Nitophyllum punctatum (Stackhouse) Greville, 1830	XS (27/04/2018).
Nitophyllum tristromaticum J.J.Rodríguez y Femenías ex Mazza, 1903	AP (27/02/2019).
Peyssonnelia sp. Decaisne, 1841	MP (09/02/2019); XS (27/04/2018).
Plocamium cartilagineum (Linnaeus) P.S.Dixon, 1967	AP (22/12/2018); XS (27/04/2018).
Plocamium sp. J.V.Lamouroux, 1813	AP (02/04/2019).
Polysiphonia opaca (C.Agardh) Moris & De Notaris, 1839	AP (02/04/2019; 13/07/2019).
Porphyra sp. C.Agardh, 1824	XS (27/04/2018).
Sphaerococcus coronopifolius Stackhouse, 1797	MP (28/09/2019).

Ochrophyta (9)	**Observations**
Colpomenia sinuosa (Mertens ex Roth) Derbès & Solier, 1851	AP (27/02/2019); XS (27/04/2018; 18/05/2018).
Cutleria adspersa (Mertens ex Roth) De Notaris, 1842	AP (13/05/2019).

Cutleria multifida (Turner) Greville, 1830	AP (27/02/2019).
Dictyota cyanoloma Tronholm, De Clerck, A. Gómez -Garreta & Rull Lluch, 2010	CE (11/05/2019; 13/07/2019); AF (09/02/2019); SF (26/01/2019); AP (22/12/2018; 26/01/2019; 13/07/2019); MP (22/12/2018; 26/01/2019; 09/02/2019; 02/03/2019; 06/04/2019; 11/05/2019; 15/06/2019; 13/07/2019; 28/09/2019; 11/07/2020); XS (27/04/2018).
Dictyota dichotoma (Hudson) J.V.Lamouroux, 1809	CE (11/05/2019; 13/07/2019); AF (09/02/2019); SF (26/01/2019); AP (24/10/2018; 22/12/2018; 26/01/2019; 10/04/2019; 11/05/2019; 15/06/2019; 13/07/2019); MP (22/12/2018; 26/01/2019; 09/02/2019; 02/03/2019; 06/04/2019; 11/05/2019; 13/07/2019; 11/07/2020); XS (25/11/2017; 05/12/2017; 27/04/2018; 03/02/2018; 18/05/2018; 06/08/2020; 19/11/2020).
Dictyota dichotoma var. *intricata* (Hudson) J.V.Lamouroux, 1809	CE (11/05/2019; 13/07/2019); AP (10/04/2019; 11/05/2019; 13/05/2019: 10/08/2019); MP (13/07/2019); XS (20/11/2019).
Halopteris scoparia (Linnaeus) Sauvageau, 1904	SF (26/01/2019); AP (21/08/2018); XS (19/11/2020).
Padina pavonica (Linnaeus) Thivy, 1960	AP (06/04/2019); XS (19/11/2020).
Ralfsia verrucosa (Areschoug) Areschoug, 1845	AF (09/02/2019); AP (24/10/2018; 22/12/2018; 26/01/2019); MP (22/12/2018; 09/02/2019).

Porifera (Fig 6c-g)

Twenty-seven species or morphotypes belonging to the classes Calcarea (8), Demospongiae (18) and Homoscleromorpha (1) inhabit the study area (Table 3). Eleven species could not be identified to an individual species level without further microscopic examination of their spicular structure or DNA sequencing. The alien calcareous sponge *Paraleucilla magna*, originally from the coasts of Brazil, was found. It has been reported in high densities in many Mediterranean locations, including the Catalan coasts, since the beginning of the 21st century. It is possible that some of the unidentified encrusting species are also introduced species. The identified species generally correspond to well-known species with a wide distribution in the western Mediterranean Sea.

Cnidaria (Figs. 6h; 7a-c)

The total census of cnidarians amounts to 21 species, distributed in 13 Anthozoa, 7 Hydrozoa and 1 Scyphozoa (Table 4). Only two of the species are pelagic: the Mauve stinger jellyfish (*Pelagia noctiluca*) and the By-the-wind-sailor (*Velella velella*), which reach this coast with the aid of sea currents and, in the case of *V. velella*, the regular easterly winds of spring. Among the Anthozoa species, 8 were sea anemones (Actiniaria) including *Exaiptasia diaphana,* gregariously on the dark areas of the walls of the bathing area, and *Anemonia viridis* on well illuminated areas such as the bathing area access stairs. A colony of the scleractinian coral, *Oculina patagonica,* was found. Though first recorded in the Mediterranean in 1966 as an alien species, it is now considered to be a native Mediterranean species with invasive behaviour (Terrón-Sigler *et al*., 2016). The alien hydroid *Pennaria disticha*, native to the western Atlantic was found. The only previous Catalan records are from Ebro Delta and Port of Roses (M. Ballesteros, pers. obs.), Sant Salvador in El Vendrell (M. Pontes, pers. obs.) and on the southern coast of Barcelona (X. Salvador, pers. obs.). Here we report, for the first time in Catalan waters, the Anthoathecata *Eleutheria dichotoma*, a microscopic specimen in the benthic jellyfish phase that was observed in the quantitative wall scraping from the Forum bathing area.

Table 3. Porifera species and observations (dd/mm/yyyy).

Calcarea species (8)	**Observations**
Clathrina coriacea (Montagu, 1814)	CE (13/07/2019); AP (20/09/2018; 22/12/2018; 26/01/2019; 10/04/2019; 13/07/2019; 10/08/2019); MP (24/11/2018; 09/02/2019; 06/04/2019); XS (27/04/2018; 16/09/2020).
Clathrina sp. Gray, 1867	XS (25/11/2017; 27/04/2018).
Clathrinida sp. Hartman, 1958	XS (20/11/2019).
Grantia compressa (Fabricius, 1780)	XS (27/04/2018).
Leucosolenia sp. Bowerbank, 1864	XS (27/04/2018).
Paraleucilla magna Klautau, Monteiro & Borojevic, 2004	MB (17/05/2018; 02/04/2019); AP (21/08/2018); MP (22/12/2018; 13/07/2019; 11/07/2020); XS (27/04/2018).
Sycon ciliatum (Fabricius, 1780)	XS (27/04/2018).
Sycon raphanus Schmidt, 1862	AP (20/09/2018; 26/01/2019; 13/07/2019); XS (27/04/2018).
Demospongiae species (18)	**Observations**
Ciocalypta penicillus Bowerbank, 1862	AP (06/04/2019); MP (09/02/2019).
Cliona celata Grant, 1826	CE (13/07/2019); AF (09/02/2019); AP (22/12/2018; 26/01/2019; 06/04/2019; 13/07/2019); MP (24/11/2018; 26/01/2019; 02/03/2019; 06/04/2019); XS (05/12/2017; 27/04/2018); MT (02/03/2019).
Cliona rhodensis Rützler & Bromley, 1981	XS (05/12/2017; 27/04/2018).
Cliona viridis (Schmidt, 1862)	AP (22/12/2018); MP (26/01/2019); MT (09/02/2019).
Crambe crambe (Schmidt, 1862)	SF (26/01/2019); AP (11/05/2019; 13/05/2019; 24/07/2019; 10/08/2019); MP (24/11/2018; 15/06/2019); XS (27/04/2018); MT (09/02/2019).
Demospongiae sp.1 Sollas, 1885	AP (22/12/2018).
Demospongiae sp.2 Sollas, 1885	XS (20/11/2019).
Demospongiae sp.3 Sollas, 1885	XS (16/09/2020).
Demospongiae sp.4 Sollas, 1885	XS (27/04/2018; 19/11/2020).
Demospongiae sp.5 Sollas, 1885	XS (20/11/2019).
Dysidea fragilis (Montagu, 1814)	AP (13/07/2019); MP (10/08/2019); XS (27/04/2018).
Haliclona (*Reniera*) *mediterranea* Griessinger, 1971	AP (24/07/2019).
Haliclona sp. Grant, 1841	XS (05/12/2017; 20/11/2019).
Ircinia oros (Schmidt, 1864)	GA (27/12/2020); MB (25/10/2018); AP (21/08/2018; 20/09/2018; 24/10/2018; 22/12/2018; 26/01/2019; 06/04/2019; 11/05/2019; 13/07/2019); MP (26/01/2019; 28/09/2019); MT (09/02/2019).
Ircinia sp. Nardo, 1833	MP (28/09/2019).
Sarcotragus fasciculatus (Pallas, 1766)	MB (25/10/2018).
Sarcotragus spinosulus Schmidt, 1862	XS (27/04/18).
Terpios fugax Duchassaing & Michelotti, 1864	MB (02/04/2019); AP (26/01/2019; 11/05/2019).
Homoscleromorpha species (1)	**Observations**
Homoscleromorpha sp. Bergquist, 1978	XS (03/02/2018; 27/04/2018; 18/05/2018).

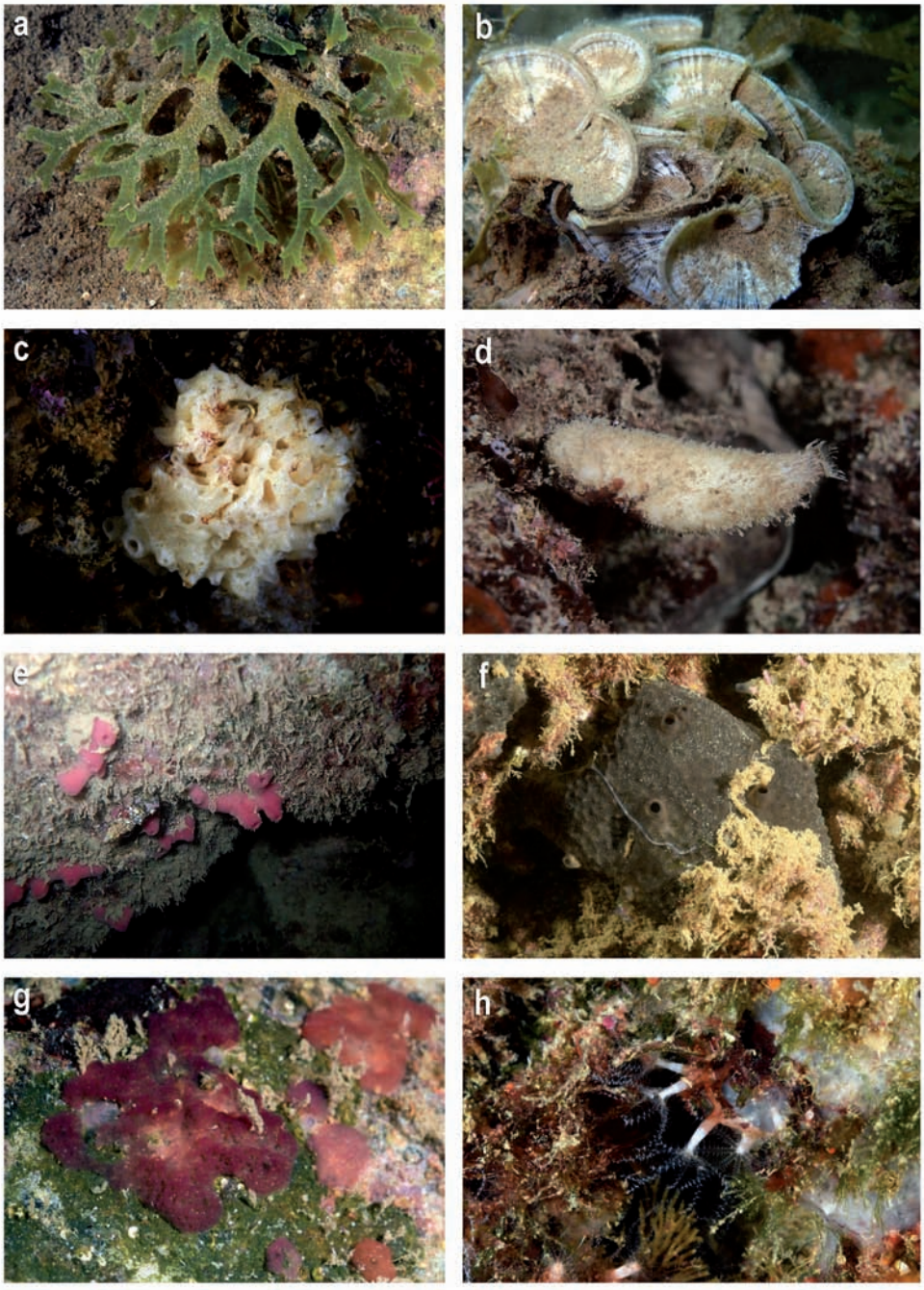

Figure 6. ALGAE. a) *Dictyota dichotoma*; b) *Padina pavonica*; PORIFERA. c) *Paraleucilla magna*; d) *Sycon ciliatum*; e) *Haliclona (Reniera) mediterranea*; f) *Sarcotragus spinosulus*; g) *Homoscleromorpha* sp.; CNIDARIA. h) *Clavularia crassa*. Pictures: M. Pontes (a, c, f, g, h); A. Parera (b,e) X. Salvador (d).

Table 4. Cnidaria species and observations (dd/mm/yyyy).

Anthozoa species (13)	**Observations**
Actinia equina (Linnaeus, 1758)	AF (09/02/2019); AP (22/12/2018; 26/01/2019; 11/05/2019); MP (28/09/2019); XS (27/04/2018).
Actinia striata Quoy & Gaimard, 1833	GA (05/01/2020); MP (11/07/2020); XS (03/02/2018; 20/11/2019; 16/09/2020).
Aiptasia mutabilis (Gravenhorst, 1831)	GA (27/04/2020; 22/11/2020;05/01/2020); MB (21/09/2018; 02/04/2019); SF (26/01/2019); AP (22/12/2018); MP (15/09/2018; 24/11/2018; 22/12/2018; 26/01/2019; 09/02/2019; 28/09/2019); XS (27/04/2018).
Aiptasiogeton hyalinus (Delle Chiaje, 1822)	XS (27/04/2018).
Anemonia viridis (Forsskål, 1775)	GA (22/11/20;21/06/20); MB (21/09/2018; 18/07/2019); SF (26/01/2019); MP (22/12/2018; 26/01/2019; 09/02/2019; 06/04/2019; 11/05/2019; 15/06/2019; 13/07/2019; 10/08/2019; 11/07/2020); XS (05/12/2017; 27/04/2018).
Aulactinia verrucosa (Pennant, 1777)	AP (10/04/2019).
Cereus pedunculatus (Pennant, 1777)	AP (24/07/2019); XS (27/04/2018).
Clavularia crassa (Milne Edwards, 1848)	MP (15/06/2019; 13/07/2019; 10/08/2019); XS (27/04/2018).
Corynactis viridis Allman, 1846	XS (05/12/2017; 27/04/2018).
Epizoanthus arenaceus (Delle Chiaje, 1836)	XS (27/04/2018).
Exaiptasia diaphana (Rapp, 1829)	GA (26/01/2019; 05/01/2020); MB (17/05/2018; 25/10/2018; 18/07/2019); CE (11/05/2019); AP (21/08/2018; 20/09/2018; 22/12/2018; 06/04/2019; 10/04/2019; 11/05/2019; 13/05/2019; 15/06/2019; 24/07/2019); MP (22/12/2018; 26/01/2019; 06/04/2019; 11/05/2019; 15/06/2019; 13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (25/11/2017; 05/12/2017; 03/02/2018; 27/04/2018; 20/11/2019); MT (02/03/2019).
Oculina patagonica de Angelis, 1908	GA (26/01/2019); MP (13/07/2019); XS (23/11/2017; 23/12/2017; 27/04/2018; 19/11/2020).
Telmatactis forskalii (Hemprich & Ehrenberg in Ehrenberg, 1834)	XS (27/04/2018).
Hydrozoa species (7)	**Observations**
Eleutheria dichotoma Quatrefages, 1842	AP (27/02/2019).
Eudendrium sp. Ehrenberg, 1834	XS (27/04/2018).
Hydractinia echinata (Fleming, 1828)	XS (03/02/2018; 27/04/2018).
Kirchenpaueria halecioides (Alder, 1859)	XS (06/08/2020).
Pennaria disticha Goldfuss, 1820	XS (23/11/2017).
Podocoryna carnea M. Sars, 1846	AP (22/12/2018; 26/01/2019).
Velella velella (Linnaeus, 1758)	XS (27/04/2018).
Scyphozoa species (1)	**Observations**
Pelagia noctiluca (Forsskål, 1775)	CE (28/09/2019); MP (28/09/2019).

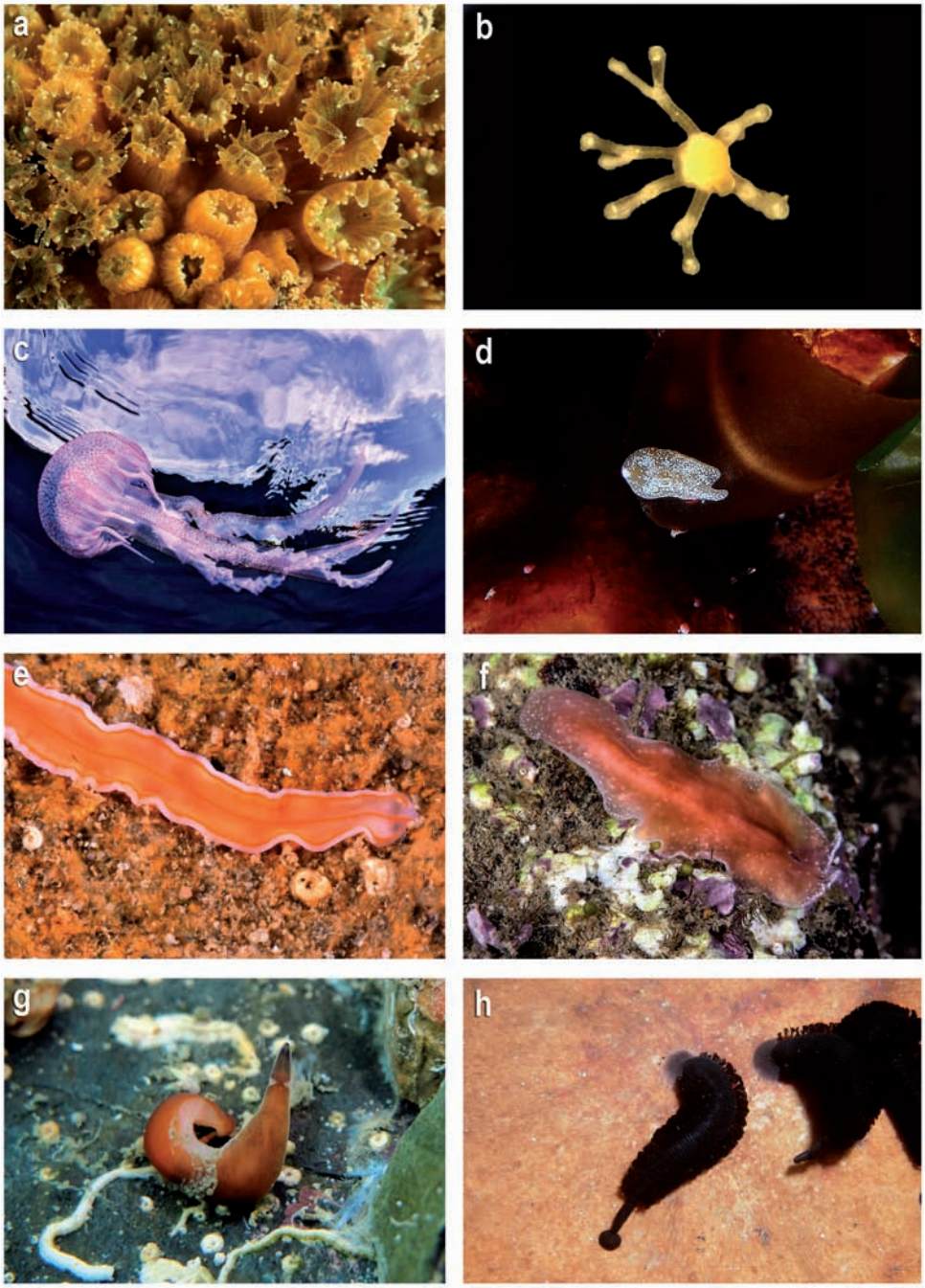

Figure 7. CNIDARIA. a) *Oculina patagonica*; b) *Eleutheria dichotoma*; c) *Pelagia noctiluca*; ACOELOMORPHA. d) Acoelomorpha; PLATHYHELMINTES. e) *Cestoplana rubrocincta*; f) *Eurylepta cornuta*; NEMERTEA. g) *Paradrepanophorus crassus*; ANNELIDA. h) *Branchelion torpedinis*. Pictures: M. Pontes (a); A. Parera (b) X. Salvador (c, d, e, f, g, h).

Acoelomorpha (Fig 7d)

This particular group of microscopic worms lack a digestive tract and live in the interstitial medium, swimming amongst the plankton or crawling on algae. In the Forum bathing area we observed specimens of several different morphotypes (Table 5) but species determination is very difficult without collection, and thus we recorded them as a single species.

Platyhelminthes (Fig. 7e-f)

The total census of flatworms amounts to 10 species (Table 5). All were common species that mostly feed on tunicates, which are very abundant in the Forum bathing area. Some species such as *Cestoplana rubrocincta*, *Discocelis tigrina*, *Eurylepta cornuta* or *Planocera ceratommata* have nocturnal behaviour and were observed at night or by examining the underside of stones.

Nemertea (Fig. 7g)

Three species of nemerteans were observed (Table 5). *Paradrepanophorus crassus* was observed in the nocturnal visual samplings, while the remaining two species appeared in the wall scrapings for the quantitative study of microfauna. Many species of nemerteans have nocturnal behaviour and are frequently found under stones during the day or moving around at night.

Table 5. Acoelomorpha, Platyhelminthes and Nemertea species, and observations (dd/mm/yyyy).

Acoelomorpha species (1)	**Observations**
Acoelomorpha spp. Ehlers, 1985	XS (27/04/2018).
Platyhelminthes species (10)	**Observations**
Cestoplana rubrocincta (Grube, 1840)	AP (11/5/2019); XS (16/09/20)
Discocelis tigrina (Blanchard, 1847)	GA (27/01/2019); XS (03/02/2018; 02/02/2019).
Eurylepta cornuta (Müller OF, 1776)	XS (19/11/2020).
Monobiceros langi Faubel, 1984	GA (24/11/2018; 11/05/2019); AP (10/04/2019); MP (28/09/2019); XS (02/02/2019); MT (06/04/2019).
Notoplana alcinoi (Schmidt, 1862)	XS (03/02/2018; 20/11/2019; 06/08/2020; 19/11/2020).
Notoplana sp. Laidlaw, 1903	XS (27/04/2018).
Planocera ceratommata (Palombi, 1936)	MP (10/08/2019).
Pseudoceros velutinus (Blanchard, 1847)	GA (06/04/2019; 11/04/2019; 18/07/2020); MB (02/04/2019; 18/07/2019); CE (13/07/2019); AP (13/07/2019); MP (11/07/2020); XS (02/02/2019; 20/11/2019; 06/08/2020).
Stylochus (*Stylochus*) *pilidium* (Goette, 1881)	MT (09/02/2019).
Thysanozoon brocchii (Risso, 1818)	GA (15/09/2018; 26/01/2019; 11/05/2019; 27/04/2020; 15/11/2020; 22/11/2020); MB (25/10/2018); CE (28/09/2019); AP (06/04/2019; 13/05/2019; 15/06/2019; 10/08/2019); MP (15/09/2018; 10/08/2019; 28/09/2019); XS (27/04/2018).
Nemertea Species (3)	**Observations**
Cephalothrix rufifrons (Johnston, 1837)	AP (24/11/2018; 27/02/2019).
Micrura purpurea (Dalyell, 1853)	AP (24/11/2018; 10/08/2019).
Paradrepanophorus crassus (Quatrefages, 1846)	XS (27/04/2018; 16/09/2020).

Sipunculida

While some authors (Shen *et al*., 2009) include the Sipunculida among the Annelida based on molecular data, others such as WoRMS still consider them as a separate phylum. Only two species of Sipunculida were found in our samplings (Table 6). *Golfingia (Golfingia) vulgaris vulgaris* was observed in visual samplings while *Phascolosoma (Phascolosoma) granulatum* occurred in the wall scraping samples for the quantitative study of microfauna. They normally live in crevices between rocks and are usually observed by sampling the underside of stones.

Annelida (Figs 7h; 8a-d)

Twenty-five species were recorded (Table 6): Polychaeta (24) and Clitellata (1). The latter was a sea leach *Branchellion torpedinis* attached to the skin of a Common torpedo (*Torpedo torpedo*). The eutrophic environment with a heavy sedimentary load favours the abundance of suspension feeding polychaete worm species. Among these species it is worth noting the purple sabella *Branchiomma luctuosum,* an alien species originating from the tropical Indo-Pacific; this species was observed frequently, including its dark-coloured and reddish-coloured gill varieties, living in the sedimentary bottom between the shore wall and the pylons and attached to sediment-covered submerged lines and structures.

In summer, numerous, whitish, spherical spawn masses, possibly of *Branchiomma luctuosum,* were observed in the southern part of the bathing area. Also noted was the presence of *Capitella capitata*, a species that lives buried in the sediment and whose presence usually indicates polluted waters and environmental deterioration according to the MEDOCC system (Bustos-Baez & Frid, 2003; Pinedo *et al*., 2012; Silva *et al*., 2017). Another rare species that lives within sand bottoms is the solitary tube worm *Diopatra neapolitana,* common in the sandy areas of the Forum bathing area.

Table 6. Sipunculida and Annelida species and observations (dd/mm/yyyy).

Sipuncula species (2)	**Observations**
Golfingia (*Golfingia*) *vulgaris vulgaris* (de Blainville, 1827)	XS (27/04/2018).
Phascolosoma (*Phascolosoma*) *granulatum* Leuckart, 1828	GA (02/03/2019); AP (24/11/2018; 27/02/2019; 10/04/2019; 11/05/2019; 13/05/2019; 10/08/2019).
Annelida species (25)	**Observations**
Alitta virens (M. Sars, 1835)	XS (16/09/2020).
Bonellia viridis Rolando, 1822	GA (15/09/2018; 27/12/2020); SF (26/01/2019); MP (24/11/2018; 13/07/2019).
Branchellion torpedinis Savigny, 1822	XS (23/11/2017).
Branchiomma luctuosum (Grube, 1870)	GA (29/08/2019; 15/09/2019; 22/11/2020; 27/12/2020); MB (17/05/2018; 21/09/2018; 25/10/2018; 02/04/2019); CE (24/11/2018; 11/05/2019); SF (26/01/2019); AP (21/08/2018; 24/10/2018; 22/12/2018; 26/01/2019; 13/05/2019; 18/07/2019); MP (24/11/2018; 22/12/2018; 26/01/2019; 09/02/2019; 02/03/2019; 06/04/2019; 11/05/2019; 15/06/2019; 13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (23/02/2016; 23/11/2017; 05/12/2017; 03/02/2018; 27/04/2018;

	18/05/2018; 20/11/2019; 06/08/2020); MT (09/02/2019; 02/03/2019; 06/04/2019).
Capitella capitata (Fabricius, 1780)	AP (27/02/2019; 11/05/2019).
Ceratonereis (*Composetia*) *costae* (Grube, 1840)	AP (27/02/2019; 13/05/2019).
Diopatra neapolitana Delle Chiaje, 1841	AP (20/06/2019).
Diopatra sp. Audouin & Milne Edwards, 1833	XS (06/08/2020).
Eupolymnia nebulosa (Montagu, 1819)	AP (27/02/2019; 10/04/2019; 11/05/2019; 24/07/2019); MP (11/05/2019); XS (27/04/2018).
Filograna implexa Berkeley, 1835	XS (27/04/2018).
Harmothoe areolata (Grube, 1860)	GA (27/12/2020); MB (05/07/2018); AP (20/09/2018; 24/11/2018; 10/04/2019; 11/05/2019; 13/07/2019); MP (11/05/2019); XS (27/04/2018).
Harmothoe extenuata (Grube, 1840)	AP (10/08/2019).
Janua heterostropha (Montagu, 1803)	MB (05/07/2018; 25/10/2018; 18/07/2019); AP (20/09/2018; 24/10/2018; 22/12/2018; 26/01/2019; 02/04/2019; 06/04/2019; 10/04/2019; 11/05/2019; 13/05/2019; 13/07/2019; 10/08/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 09/02/2019; 02/03/2019; 06/04/2019); XS (25/11/2017; 05/12/2017; 18/05/2018; 02/02/2019; 20/11/2019; 06/08/2020; 16/09/2020; 19/11/2020); MT (09/02/2019; 02/03/2019).
Marphysa sanguinea (Montagu, 1813)	AP (26/01/2019; 13/05/2019).
Nereis sp. Linnaeus, 1758	AP (27/02/2019); XS (27/04/2018).
Polycirrus sp. Grube, 1850	AF (09/02/2019); AP (26/01/2019); XS (05/12/2017).
Polyophthalmus pictus (Dujardin, 1839)	AP (27/02/2019; 13/05/2019).
Protula sp. Risso, 1826	XS (25/11/2017; 05/12/2017; 27/04/2018).
Protula tubularia (Montagu, 1803)	MB (21/09/2018); MP (15/09/2018; 22/12/2018; 10/08/2019; 11/07/2020).
Sabella spallanzanii (Gmelin, 1791)	MB (25/10/2018); CE (28/09/2019); AP (20/09/2018; 24/10/2018; 06/04/2019; 15/06/2019); MP (24/11/2018; 22/12/2018; 02/03/201); XS (19/11/2020).
Salmacina dysteri (Huxley, 1855)	AP (10/08/2019); MP (15/06/2019); XS (06/08/2020).
Serpula lobiancoi Rioja, 1917	XS (27/04/2018).
Serpula vermicularis Linnaeus, 1767	AP (27/02/2019; 13/07/2019); MP (22/12/2018; 09/02/2019); XS (27/04/2018).
Spirobranchus triqueter (Linnaeus, 1758)	AP (21/08/2018; 20/09/2018; 24/10/2018; 22/12/2018; 26/01/2019; 06/04/2019; 10/04/2019; 11/05/2019; 13/05/2019; 13/07/2019;10/08/2019); MP (15/09/2018; 24/11/2018; 06/04/2019); XS (23/11/2017; 03/02/2018; 27/04/2018; 02/02/2019; 20/11/2019; 06/08/2020; 16/09/2020); MT (09/02/2019).
Vermiliopsis infundibulum (Philippi, 1844)	AP (24/10/2018); MP (15/09/2018).

Mollusca (Figs 8e-f; 9a-h; 10a-h; 11a-h; 12a-e)

Mollusca was the most biodiverse group at the species level in the Forum bathing area, with a total of 176 identified species including 6 Polyplacophora, 42 Bivalvia, 123 Gastropoda and 5 Cephalopoda (Table 7). Some of these species were observed as empty shells only, but since the study area is an almost closed marine ecosystem, we assume that these species can also be found

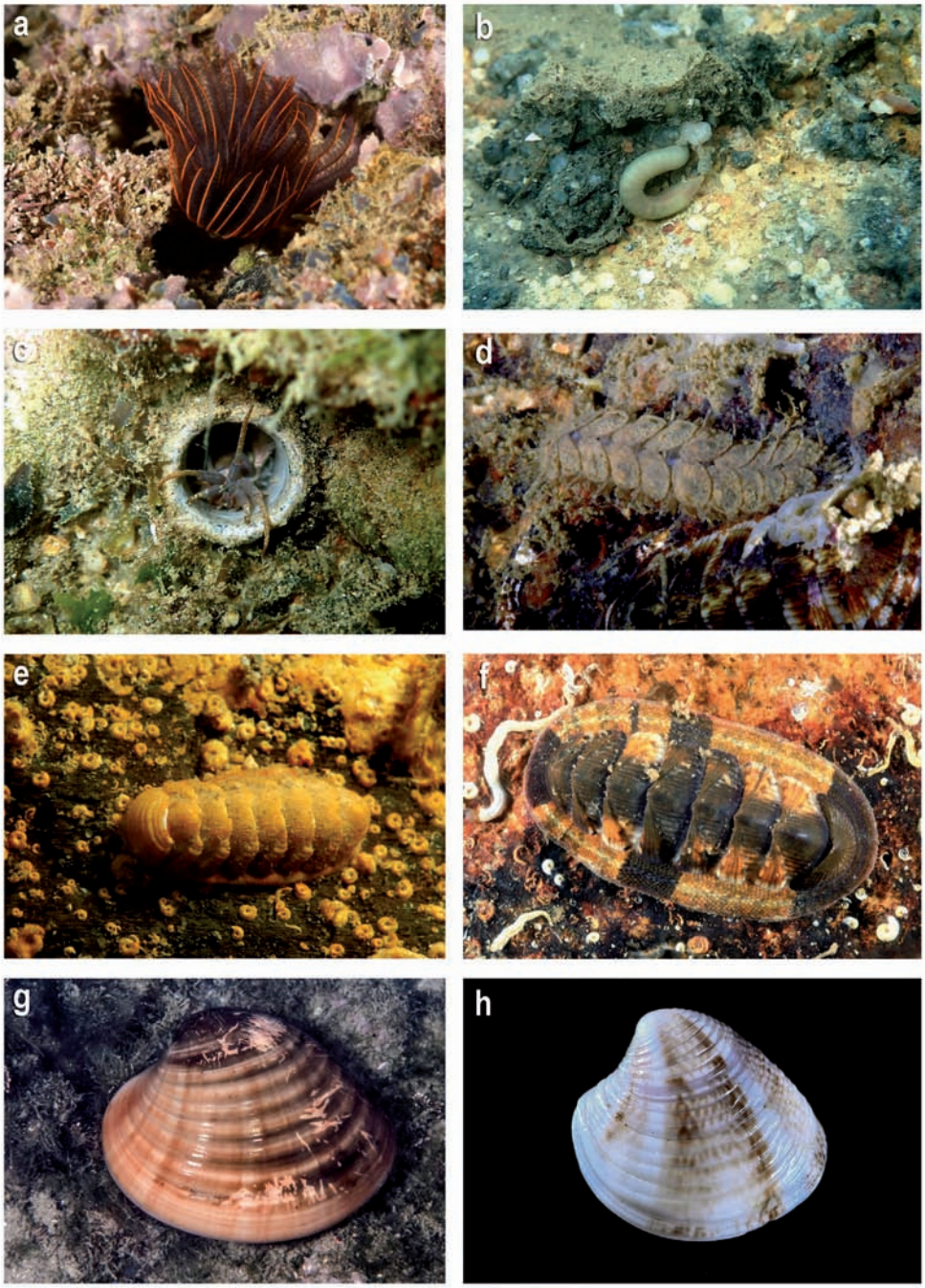

Figure 8. ANNELIDA. a) *Branchiomma luctuosum*; b) *Capitella capitata*; c) *Diopatra neapolitana*; d) *Harmothoe areolata*; MOLLUSCA. e) *Lepidopleurus cajetanus*; f) *Rhyssoplax olivacea*; g) *Callista chione*; h) *Chamelea gallina*. Pictures: M. Pontes (a, d, e, f); A. Parera (b,c) X. Salvador (g, h).

alive within it. The presence of nine species of bivalves of commercial interest is remarkable: *Callista chione, Chamelea gallina, Donax trunculus, Ensis ensis, Ostrea edulis, Polititapes aureus, Venerupis geographica, Venus verrucosa* and *Mytilus galloprovincialis.* Also notable is the presence of a protected species, the date mussel *Lithophaga lithophaga,* whose collection is forbidden in Spain because it requires breaking the substrate rock to get to the animal, destroying the biological community. Surprisingly, during the May 2018 sampling, six specimens of fan mussel *Pinna nobilis* were found at 1.5 m depth in the area between the wall of the bathing area and the pylons, four specimens were alive and two dead. Due to the disease caused by the protozoan *Haplosporidium pinnae* that, combined with a mycobacterial disease (Carella *et al*., 2019), is depleting *Pinna nobilis* stocks across the Mediterranean (Catanese *et al*., 2018; Panarese *et al*., 2019), the remaining living specimens in the Forum bathing area had already died as of the end of 2018, with some of their empty shells still visible throughout 2019.

Within the Gastropoda, the Heterobranchia were well represented in the area with 53 species, with the remarkable presence of two alien species: the ragged sea hare *Bursatella leachii* and the small polycerid nudibranch *Polycerella emertoni* that lives in the seasonally very abundant colonies of the bryozoan *Amathia verticillata*. Another remarkable heterobranch observed alive was the rare Siphonariida *Williamia gussoni*, a false limpet often documented only by the shell, with no known previous pictures of living specimens. Some species of micromolluscs only appeared in quantitative scrapings of wall surfaces and pylons, such as *Caecum* spp., *Doto rosea*, *Odostomia unidentata*, *Pusillina philippi*, *Retusa truncatula*, *Rissoa* spp., *Rissoina bruguierei*, *Runcina africana* and *Turbonilla pusilla.*

Table 7. Mollusca species and observations (dd/mm/yyyy).

Polyplacophora species (6)	**Observations**
Acanthochitona crinita (Pennant, 1777)	CE (28/09/2019); AP (13/05/2019); XS (27/04/2018).
Acanthochitona fascicularis (Linnaeus, 1767)	AP (24/11/2018); XS (16/09/2020).
Lepidochitona caprearum (Scacchi, 1836)	AP (21/08/2018; 27/02/2019; 13/05/2019; 10/08/2019).
Lepidopleurus cajetanus (Poli, 1791)	GA (27/02/2019).
Rhyssoplax corallina (Risso, 1826)	GA (21/06/2020); AP (24/10/2018; 22/12/2018; 26/01/2019; 11/05/2019); XS (27/04/2018); MT (02/03/2019).
Rhyssoplax olivacea (Spengler, 1797)	GA (24/11/2018; 02/03/2019; 22/11/2020; 27/12/2020); MB (05/07/2018; 25/10/2018; 02/04/2019; 18/07/2019); CE (11/05/2019; 13/07/2019); AP (20/09/2018; 24/10/2018; 22/12/2018; 26/01/2019; 06/04/2019; 10/04/2019; 11/05/2019; 13/07/2019); MP (15/09/2018; 22/12/2018; 09/02/2019; 02/03/2019; 06/04/2019; 11/05/2019; 15/06/2019; 13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (23/02/2016; 27/04/2018;18/05/2018; 20/11/2019; 06/08/2020); MT (09/02/2019; 02/03/2019).
Bivalvia species (42)	**Observations**
Abra alba (W. Wood, 1802)	GA (22/12/2018); AP (22/12/2018).
Anomia ephippium Linnaeus, 1758	GA (24/11/2018; 02/03/2019; 27/04/2020); MB (05/07/2018; 21/09/2018; 02/04/2019;

	18/07/2019); AP (24/11/2018; 11/05/2019; 13/05/2019; 10/08/2019); MP (06/04/2019); XS (05/12/2017; 27/04/2018;18/05/2018; 02/02/2019; 20/11/2019; 16/09/2020); MT (02/03/2019).
Arca noae Linnaeus, 1758	GA (13/10/2018; 30/11/2019; 04/11/2020; 15/11/2020); MB (21/09/2018); AP (22/12/2018; 26/01/2019); MP (26/01/2019; 09/02/2019; 11/05/2019; 15/06/2019; 28/09/2019); XS (27/04/2018).
Barbatia barbata (Linnaeus, 1758)	GA (11/05/2019); AP (24/11/2018; 26/01/2019); XS (27/04/2018).
Callista chione (Linnaeus, 1758)	GA (26/01/2019; 27/12/2020); XS (19/11/2020).
Chama gryphoides Linnaeus, 1758	GA (11/05/2019; 10/04/2019); AP (10/04/2019; 13/07/2019; 10/08/2019); XS (27/04/2018; 20/11/2019).
Chamelea gallina (Linnaeus, 1758)	XS (19/11/2020).
Ctena decussata (O. G. Costa, 1829)	GA (01/12/2018).
Donax trunculus Linnaeus, 1758	MP (13/07/2019).
Ensis ensis (Linnaeus, 1758)	MP (26/01/2019).
Galeomma turtoni W. Turton, 1825	GA (18/07/2020); XS (27/04/2018).
Gari depressa (Pennant, 1777)	GA (06/04/2019); MP (15/06/2019); XS (19/11/2020).
Hiatella rugosa (Linnaeus, 1767)	GA (22/12/2018; 27/12/2020); AP (24/11/2018).
Irus irus (Linnaeus, 1758)	AP (24/11/2018; 10/08/2019).
Lima lima (Linnaeus, 1758)	XS (27/04/2018).
Limaria hians (Gmelin, 1791)	GA (08/01/2019; 24/02/2019; 06/04/2019; 04/11/2020); MB (21/09/2018); CE (13/07/2019); AP (15/06/2019; 13/07/2019); MP (09/02/2019; 06/04/2019; 11/05/2019; 11/07/2020); XS (20/11/2019).
Limaria tuberculata (Olivi, 1792)	GA (22/11/2020; 16/01/2021); XS (19/11/2020).
Limatula subauriculata (Montagu, 1808)	GA (27/12/2020).
Lithophaga lithophaga (Linnaeus, 1758)	AP (24/11/2018; 27/02/2019; 13/05/2019; 10/08/2019); XS (20/11/2019).
Loripes orbiculatus Poli, 1795	GA (16/01/2021); XS (19/11/2020).
Macomangulus tenuis (da Costa, 1778)	GA (22/11/2020).
Mactra glauca Born, 1778	GA (16/01/2021).
Mimachlamys varia (Linnaeus, 1758)	GA (11/05/2019; 30/11/2019; 04/11/2020); MB (21/09/2018); CE (13/07/2019); SF (26/01/2019); AP (20/09/2018; 10/04/2019; 13/05/2019; 13/07/2019; 10/08/2019); MP (22/12/2018; 15/06/2019; 10/08/2019); XS (27/04/2018; 20/11/2019).
Moerella donacina (Linnaeus, 1758)	GA (16/01/2021).
Musculus costulatus (Risso, 1826)	MB (18/07/2019); AP (24/11/2018; 13/05/2019).
Mytilus galloprovincialis Lamarck, 1819	AP (22/12/2018; 13/05/2019); MP (09/02/2019; 11/05/2019; 13/07/2019; 10/08/2019; 11/07/2020); XS (19/11/2020).
Ostrea edulis Linnaeus, 1758	CE (13/07/2019); MP (26/01/2019; 09/02/2019); XS (27/04/2018).
Papillicardium papillosum (Poli, 1791)	GA (16/01/2021).
Parvicardium exiguum (Gmelin, 1791)	GA (22/12/2018); AP (27/02/2019).
Parvicardium scriptum (Bucquoy, Dautzenberg & Dollfus, 1892)	AP (24/11/2018; 27/02/2019).
Peronaea planata (Linnaeus, 1758)	GA (22/12/2018; 27/12/2020); XS (19/11/2020).

Pinna nobilis Linnaeus, 1758	GA (16/05/2018); MB (17/05/2018); SF (26/01/2019); AP (21/08/2018; 20/09/2018); MP (22/12/2018; 26/01/2019; 09/02/2019); XS (23/02/2016; 23/12/2017; 27/04/2018).
Polititapes aureus (Gmelin, 1791)	XS (19/11/2020).
Rocellaria dubia (Pennant, 1777)	AP (24/11/2018; 27/02/2019; 10/04/2019; 11/05/2019; 13/05/2019; 24/07/2019; 10/08/2019); XS (27/04/2018; 02/02/2019).
Scrobicularia plana (da Costa, 1778)	AP (24/10/2018).
Spisula subtruncata (da Costa, 1778)	AP (24/11/2018; 13/05/2019).
Spondylus gaederopus Linnaeus, 1758	MP (11/07/2020).
Striarca lactea (Linnaeus, 1758)	GA (11/05/2019; 05/01/2020; 27/12/2020); AP (20/09/2018; 24/10/2018; 22/12/2018; 26/01/2019; 27/02/2019; 06/04/2019; 10/04/2019; 11/05/2019; 13/05/2019; 10/08/2019); MP (24/11/2018; 22/12/2018); XS (20/11/2019); MT (09/02/2019).
Talochlamys pusio (Linnaeus, 1758)	XS (27/04/2018).
Thracia corbuloides Deshayes, 1824	GA (16/01/2021).
Venerupis sp. Lamarck, 1818	XS (27/04/2018).
Venus verrucosa Linnaeus, 1758	GA (22/12/2018; 11/05/2019; 27/12/2020); AP (21/08/2018; 10/04/2019; 13/05/2019); MP (11/05/2019; 15/06/2019).

Gastropoda species (123)	**Observations**
Aeolidiella alderi (Cocks, 1852)	XS (25/11/2017; 03/02/2018).
Aglaja tricolorata Renier, 1807	GA (25/07/2020); AP (24/07/2019); EC (24/07/2019).
Aldisa banyulensis Pruvot-Fol, 1951	MPE (27/04/2019).
Alvania cimex (Linnaeus, 1758)	GA (22/12/2018); AP (24/11/2018; 27/02/2019; 13/05/2019; 10/08/2019).
Alvania discors (T. Brown, 1818)	GA (27/12/2020; 16/01/2021); AP (27/02/2019); XS (06/08/2020).
Alvania lineata Risso, 1826	GA (27/12/2020; 16/01/2021); AP (13/05/2019).
Alvania lucinae Oberling, 1970	AP (27/02/2019).
Antiopella cristata (Delle Chiaje, 1841)	CP (16/05/2018); XS (27/04/2018).
Aplus dorbignyi (Payraudeau, 1826)	OC (11/05/2019).
Aplysia depilans Gmelin, 1791	AP (15/06/2019); MP (11/07/2020); XS (25/11/2017; 05/12/2017; 03/02/2018; 27/04/2018; 18/05/2018; 19/11/2020).
Aplysia fasciata Poiret, 1789	XS (23/11/2017; 05/12/2017; 27/04/2018).
Aplysia punctata (Cuvier, 1803)	MB (17/05/2018; 05/07/2018; 18/07/2019); CE (13/07/2019); AP (02/04/2019; 13/05/2019; 15/06/2019; 13/07/2019; 18/07/2019); XS (27/04/2018).
Berghia coerulescens Laurillard, 1832)	CE (11/05/2019); AP (11/05/2019); EC: (27/04/2019; 11/05/2019); XS (23/02/2016; 03/02/2018; 18/05/2018).
Berghia verrucicornis (A. Costa, 1867)	MB (18/07/2019); AP (18/07/2019); XS (18/05/2018; 06/08/2020; 16/09/2020).
Berthella perforata (Philippi, 1844)	XS (23/11/2017).
Berthella stellata (Risso, 1826)	XS (25/11/2017; 05/12/2017; 03/02/2018; 27/04/2018; 18/05/2018; 02/02/2019; 20/11/2019; 16/09/2020).
Berthellina edwardsii (Vayssière, 1897)	XS (05/12/2017; 20/11/2019; 16/09/2020).
Bittium latreillii (Payraudeau, 1826)	AP (10/04/2019); XS (20/11/2019).
Bittium reticulatum (da Costa, 1778)	GA (22/12/2018; 06/04/2019; 10/04/2019;

	15/11/2020; 27/12/2020); AP (24/11/2018; 11/05/2019; 13/05/2019); XS (05/12/2017; 27/04/2018; 20/11/2019).
Bittium sp. Gray, 1847	AP (27/02/2019).
Bulla striata Bruguière, 1792	GA (22/12/2018); AP (24/11/2018; 15/06/2019; 24/07/2019); MP (15/06/2019; 10/08/2019; 11/07/2020); XS (03/02/2018; 27/04/2018; 02/02/2019; 20/11/2019).
Bursatella leachii Blainville, 1817	GA (22/11/2020); MB (17/05/2018); AP (21/08/2018); MP (15/09/2018); XS (23/11/2017; 25/11/2017; 05/12/2017; 23/12/2017; 03/02/2018; 27/04/2018; 20/11/2019; 19/11/2020).
Cabestana cutacea (Linnaeus, 1767)	MP (24/11/2018); XS (27/04/2018).
Caecum auriculatum de Folin, 1868	GA (16/01/2021).
Caecum trachea (Montagu, 1803)	GA (16/01/2021).
Caliphylla mediterranea A. Costa, 1867	XS (05/12/2017; 19/11/2020).
Calma gobioophaga Calado & Urgorri, 2002	AP (27/04/2019).
Caloria quatrefagesi (Vayssière, 1888)	XS (23/11/2017; 25/11/2017; 05/12/2017; 03/02/2018; 27/04/2018; 20/11/2019; 19/11/2020).
Camachoaglaja africana (Pruvot-Fol, 1953)	XS (06/08/2020; 16/09/2020).
Cerithium vulgatum Bruguière, 1792	GA (02/03/2019; 11/05/2019; 22/11/2020; 10/12/2020; 27/12/2020); MB (17/05/2018; 05/07/2018; 21/09/2018; 02/04/2019; 18/07/2019); CE (24/11/2018; 11/05/2019); AF (09/02/2019); SF (26/01/2019); AP (12/07/2018; 20/09/2018; 24/10/2018; 24/11/2018; 22/12/2018; 26/01/2019; 27/02/2019; 13/05/2019; 13/07/2019; 18/07/2019; 24/07/2019; 10/08/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 26/01/2019; 09/02/2019; 02/03/2019; 06/04/2019; 11/05/2019; 15/06/2019; 13/07/2019; 10/08/2019; 11/07/2020); XS (27/04/2018; 02/02/2019; 20/11/2019; 19/11/2020); MT (09/02/2019; 02/03/2019).
Clanculus corallinus (Gmelin, 1791)	AP (24/11/2018; 27/02/2019; 11/05/2019).
Clanculus cruciatus (Linnaeus, 1758)	AP (13/05/2019; 10/08/2019).
Clanculus jussieui (Payraudeau, 1826)	GA (02/03/2019; 15/11/2020; 27/12/2020); AP (24/11/2018; 27/02/2019; 13/05/2019; 10/08/2019); MP (15/06/2019); XS (03/02/2018; 27/04/2018).
Columbella rustica (Linnaeus, 1758)	XS (27/04/2018).
Cratena peregrina (Gmelin, 1791)	XS (05/12/2017).
Dendrodoris sp. Ehrenberg, 1831	GA (26/01/2019; 28/02/2019; 11/05/2019;20/05/2020); MB (02/04/2019; 18/07/2019); CE (11/05/2019); AP (27/02/2019; 02/04/2019; 11/05/2019; 18/07/2019); MP (11/05/2019); XS (27/04/2018; 02/02/2019).
Dendropoma cristatum (Biondi, 1859)	AP (24/11/2018; 27/02/2019; 13/05/2019; 10/08/2019).
Diodora gibberula (Lamarck, 1822)	AP (26/01/2019); XS (23/11/2017; 20/11/2019).
Diodora graeca (Linnaeus, 1758)	GA (15/09/2018; 24/02/2019; 02/03/2019; 27/04/2020); AP (06/04/2019; 10/04/2019; 11/05/2019; 13/05/2019); MP (06/04/2019; 11/05/2019); XS (03/02/2018; 27/04/2018; 16/09/2020).
Diodora italica (Defrance, 1820)	XS (05/12/2017; 03/02/2018; 06/08/2020; 16/09/2020).

Doris verrucosa Linnaeus, 1758	AP (13/05/2019).
Doto rosea Trinchese, 1881	AP (27/02/2019).
Echinolittorina punctata (Gmelin, 1791)	XS (20/11/2019; 06/08/2020).
Edmundsella pedata(Montagu, 1816)	XS (27/04/2018).
Elysia flava Verrill, 1901	AP (24/07/2019); XS (02/02/2019).
Elysia timida (Risso, 1818)	AP (27/02/2019); XS (23/11/2017).
Elysia viridis (Montagu, 1804)	XS (23/11/2017).
Emarginula sp. Lamarck, 1801	XS (27/04/2018).
Episcomitra cornicula (Linnaeus, 1758)	CE (11/05/2019); MT (09/02/2019).
Epitonium clathrus (Linnaeus, 1758)	GA (01/12/2018).
Epitonium turtonis (W. Turton, 1819)	MP (11/05/2019).
Eulimella acicula (Philippi, 1836)	AP (13/05/2019).
Facelina auriculata (Müller, 1776)	XS (27/04/2018).
Favorinus branchialis (Rathke, 1806)	XS (25/11/2017; 27/04/2018; 18/05/2018).
Felimare picta (Philippi, 1836)	GA (22/11/2020; 15/11/2020); MB (21/09/2018); CE (28/09/2019); AP (21/08/2018; 20/09/2018); MP (13/07/2019; 28/09/2019; 11/07/2020); XS (23/11/2017; 25/11/2017; 06/08/2020; 19/11/2020).
Felimida krohni (Vérany, 1846)	GA (15/09/2019; 20/05/2020); CE (13/07/2019); AP (13/07/2019); MP (22/12/2018); XS (27/04/2018; 18/05/2018).
Fissurella nubecula(Linnaeus, 1758)	GA (22/12/2018; 02/03/2019; 21/06/2020; 04/11/2020; 15/11/2020); AP (24/11/2018; 22/12/2018; 26/01/2019; 27/02/2019; 13/05/2019; 10/08/2019); XS (27/04/2018; 16/09/2020); MT (09/02/2019; 02/03/2019).
Flabellina cavolini (Vérany, 1846)	XS (05/12/2017; 27/04/2018).
Flabellina gaditana (Cervera, García-Gómez & García, 1987)	XS (23/11/2017).
Geitodoris planata (Alder & Hancock, 1846)	GA (15/11/2020); XS (05/12/2017).
Gibbula ardens (Salis Marschlins, 1793)	XS (20/11/2019).
Gibbula sp. Risso, 1826	AP (24/11/2018; 27/02/2019; 13/05/2019; 10/08/2019); XS (20/11/2019); MT (09/02/2019).
Gibbula turbinoides (Deshayes, 1835)	AP (24/11/2018; 27/02/2019; 10/08/2019).
Goniodoris castanea Alder & Hancock, 1845	XS (03/02/2018; 18/05/2018; 02/02/2019; 20/11/2019).
Haliotis tuberculata Linnaeus, 1758	GA (22/12/2018; 11/05/2019; 27/12/2020); MB (05/07/2018; 18/07/2019); CE (11/05/2019; 28/09/2019); AP (20/09/2018; 26/01/2019; 02/04/2019; 06/04/2019; 10/04/2019; 11/05/2019; 13/05/2019; 13/07/2019); MP (09/02/2019; 02/03/2019; 06/04/2019; 15/06/2019; 13/07/2019; 28/09/2019); XS (27/04/2018); MT (02/03/2019).
Haminoea hydatis (Linnaeus, 1758)	XS (27/04/2018).
Haminoea orbignyana (Férussac, 1822)	XS (16/09/2020).
Haminoea orteai Talavera, Murillo & Templado, 1987	XS (25/11/2017; 05/12/2017; 03/02/2018; 27/04/2018; 20/11/2019; 06/08/2020; 16/09/2020; 19/11/2020).
Hexaplex trunculus (Linnaeus, 1758)	GA (06/02/2019; 15/10/2019; 30/11/2019; 27/12/2020; 22/11/2020; 04/11/2020; 27/12/2020); MB (05/07/2018; 25/10/2018; 02/04/2019; 18/07/2019); CE (11/05/2019); SF (26/01/2019); AP (24/10/2018; 24/11/2018; 27/02/2019; 06/04/2019; 10/04/2019; 11/05/2019; 13/05/2019; 18/07/2019; 10/08/2019); MP (26/01/2019; 09/02/2019;

	02/03/2019; 11/05/2019; 13/07/2019; 28/09/2019); XS (27/04/2018; 19/11/2020); MT (09/02/2019; 02/03/2019; 06/04/2019).
Jorunna evansi (Eliot, 1906)	AP (20/09/2018).
Jorunna tomentosa (Cuvier, 1804)	AP (20/09/2018); XS (27/04/2018).
Lamellaria perspicua (Linnaeus, 1758)	GA (27/12/2020); MT (06/04/2019).
Luria lurida (Linnaeus, 1758)	GA (15/01/2021).
Manzonia crassa (Kanmacher, 1798)	GA (27/12/2020).
Melarhaphe neritoides (Linnaeus, 1758)	GA (16/01/2021); AP (21/08/2018; 24/10/2018); XS (20/11/2019; 06/08/2020).
Mitrella scripta (Linnaeus, 1758)	AP (24/11/2018; 27/02/2019; 13/05/2019).
Monoplex parthenopeus (Salis Marschlins, 1793)	MP (11/07/2020).
Muricopsis cristata (Brocchi, 1814)	AP (11/05/2019; 24/11/2018); MP (24/11/2018).
Notocochlis dillwynii (Payraudeau, 1826)	GA (01/12/2018).
Ocenebra edwardsii (Payraudeau, 1826)	GA (22/11/2020; 10/04/2019); AP (13/05/2019).
Ocenebra erinaceus (Linnaeus, 1758)	GA (11/05/2019); MB (02/04/2019); AP (24/11/2018; 10/08/2019).
Odostomia unidentata (Montagu, 1803)	GA (27/12/2020).
Okenia longiductis Pola, Paz-Sedano, Macali, Minchin, Marchini, Vitale, Licchelli & Crocetta, 2019	XS (23/11/2017; 25/11/2017; 06/08/2020).
Patella caerulea Linnaeus, 1758	GA (27/12/2020); AF (09/02/2019); AP (21/08/2018; 24/10/2018; 22/12/2018; 26/01/2019; 27/02/2019; 06/04/2019; 13/05/2019).
Patella rustica Linnaeus, 1758	AP (02/04/2019).
Patella sp. Linnaeus, 1758	AP (24/10/2018); XS (27/04/2018).
Phorcus richardi (Payraudeau, 1826)	AP (22/12/2018); MP (24/11/2018; 09/02/2019; 06/04/2019); XS (27/04/2018).
Phorcus turbinatus (Born, 1778)	AP (21/08/2018; 24/11/2018; 27/02/2019; 13/05/2019; 10/08/2019).
Placida cremoniana (Trinchese, 1892)	CE (28/09/2019); AP (22/12/2018; 11/05/2019); MP (22/12/2018; 28/09/2019); XS (23/11/2017; 25/11/2017; 05/12/2017; 20/11/2019; 16/09/2020).
Placida dendritica (Alder & Hancock, 1843)	AP (27/02/2019); XS (23/11/2017).
Placida tardyi (Trinchese, 1874)	XS (23/11/2017; 25/11/2017; 05/12/2017; 03/02/2018; 20/11/2019; 06/08/2020; 19/11/2020).
Placida verticilata Ortea, 1982	XS (20/11/2019).
Placida viridis (Trinchese, 1874)	XS (20/11/2019).
Polycerella emertoni A. E. Verrill, 1880	MB (18/07/2019); AP (18/07/2019).
Pusillina philippi (Aradas & Maggiore, 1844)	AP (27/02/2019).
Retusa truncatula (Bruguière, 1792)	GA (27/12/2020).
Rissoa guerinii Récluz, 1843	GA (27/12/2020).
Rissoa similis Scacchi, 1836	GA (27/12/2020).
Rissoina bruguieri (Payraudeau, 1826)	GA (24/11/2018).
Runcina africana Pruvot-Fol, 1953	XS (20/11/2019; 06/08/2020).
Runcina brenkoae T. E. Thompson, 1980	MB (18/07/2019); AP (02/04/2019; 18/07/2019).
Runcina marcosi Araújo, Pola, Malaquias & Cervera, 2019	AP (02/04/2019).
Spurilla neapolitana (Delle Chiaje, 1841)	CE (13/07/2019); AP (11/05/2019; 13/07/2019); XS (25/11/2017; 05/12/2017; 03/02/2018; 27/04/2018; 02/02/2019; 06/08/2020).
Steromphala adansonii (Payraudeau, 1826)	AP (26/01/2019; 27/02/2019; 10/04/2019; 24/11/2018); MP (02/03/2019).
Steromphala divaricata (Linnaeus, 1758)	XS (27/04/2018).
Steromphala rarilineata (Michaud, 1829)	GA (15/11/2020).

Steromphala varia (Linnaeus, 1758)	GA (01/12/2018; 30/11/2019; 27/12/2020); AP (24/11/2018).
Stramonita haemastoma (Linnaeus, 1767)	GA (24/02/2019; 11/05/2019); MB (21/09/2018; 02/04/2019); AP (21/08/2018; 26/01/2019); MP (24/11/2018; 22/12/2018; 26/01/2019; 06/04/2019; 15/06/2019; 13/07/2019; 10/08/2019); XS (27/04/2018).
Tayuva lilacina (Gould, 1852)	MB (25/10/2018); AP (20/09/2018; 24/10/2018); XS (25/11/2017; 03/02/2018; 27/04/2018; 20/11/2019).
Thuridilla hopei (Vérany, 1853)	GA (02/03/2019); CE (11/05/2019; 13/07/2019; 28/09/2019); AP (06/04/2019; 10/04/2019; 11/05/2019; 10/08/2019); MP (15/09/2018; 22/12/2018; 02/03/2019; 11/05/2019; 28/09/2019); XS (16/09/2020); MT (02/03/2019).
Tritia corniculum (Olivi, 1792)	GA (02/03/2019; 04/11/2020; 15/11/2020; 10/12/2020); AP (24/11/2018; 27/02/2019; 10/04/2019; 11/05/2019; 13/05/2019; 13/07/2019; 18/07/2019; 10/08/2019); MP (02/03/2019; 06/04/2019; 15/06/2019); XS (20/11/2019).
Tritia cuvierii (Payraudeau, 1826)	AP (11/05/2019).
Tritia incrassata (Strøm, 1768)	GA (24/11/2018; 10/04/2019; 05/01/2020; 22/12/2020); AP (24/11/2018; 27/02/2019; 10/04/2019; 13/05/2019; 13/07/2019; 10/08/2019); MP (02/03/2019).
Tritia mutabilis (Linnaeus, 1758)	OC (11/05/2019); XS (16/09/2020).
Tritia neritea (Linnaeus, 1758)	GA (10/04/2019); AP (10/04/2019; 13/07/2019); XS (05/12/2017).
Tritia nitida (Jeffreys, 1867)	CG (09/02/2019).
Tritia pellucida (Risso, 1826)	XS (05/12/2017).
Tritia reticulata (Linnaeus, 1758)	GA (23/12/2018; 11/04/2019; 27/12/2020); AP (22/12/2018; 27/02/2019; 06/04/2019; 11/05/2019); XS (20/11/2019).
Trivia monacha (da Costa, 1778)	GA (23/06/2018).
Trophonopsis muricata (Montagu, 1803)	AP (20/09/2018; 24/10/2018; 22/12/2018); XS (27/04/2018; 16/09/2020).
Turbonilla pusilla (Philippi, 1844)	GA (16/01/2021).
Vermetus triquetrus Bivona-Bernardi, 1832	MB (25/10/2018; 18/07/2019); AP (24/11/2018; 27/02/2019; 13/05/2019; 10/08/2019); MP (24/11/2018); XS (27/04/2018; 19/11/2020).
Williamia gussoni (Costa O. G., 1829)	XS (27/04/2018).

Cephalopoda species (5)	**Observations**
Callistoctopus macropus (Risso, 1826)	XS (23/11/2017; 25/11/2017; 19/11/2020).
Loligo vulgaris Lamarck, 1798	SF (26/01/2019).
Octopus vulgaris Cuvier, 1797	GA (21/06/2020; 22/11/2020); CE (24/11/2018); AP (11/05/2019; 13/07/2019; 24/07/2019); MP (10/08/2019; 28/09/2019; 11/07/2020); XS (23/11/2017; 25/11/2017; 05/12/2017; 20/11/2019; 19/11/2020).
Sepia officinalis Linnaeus, 1758	GA (10/04/2019); CE (11/05/2019); AP (27/02/2019; 02/04/2019; 11/05/2019); MP (02/03/2019; 06/04/2019; 11/05/2019); XS (05/12/2017).
Sepiola rondeletii Leach, 1817	XS (27/04/2018).

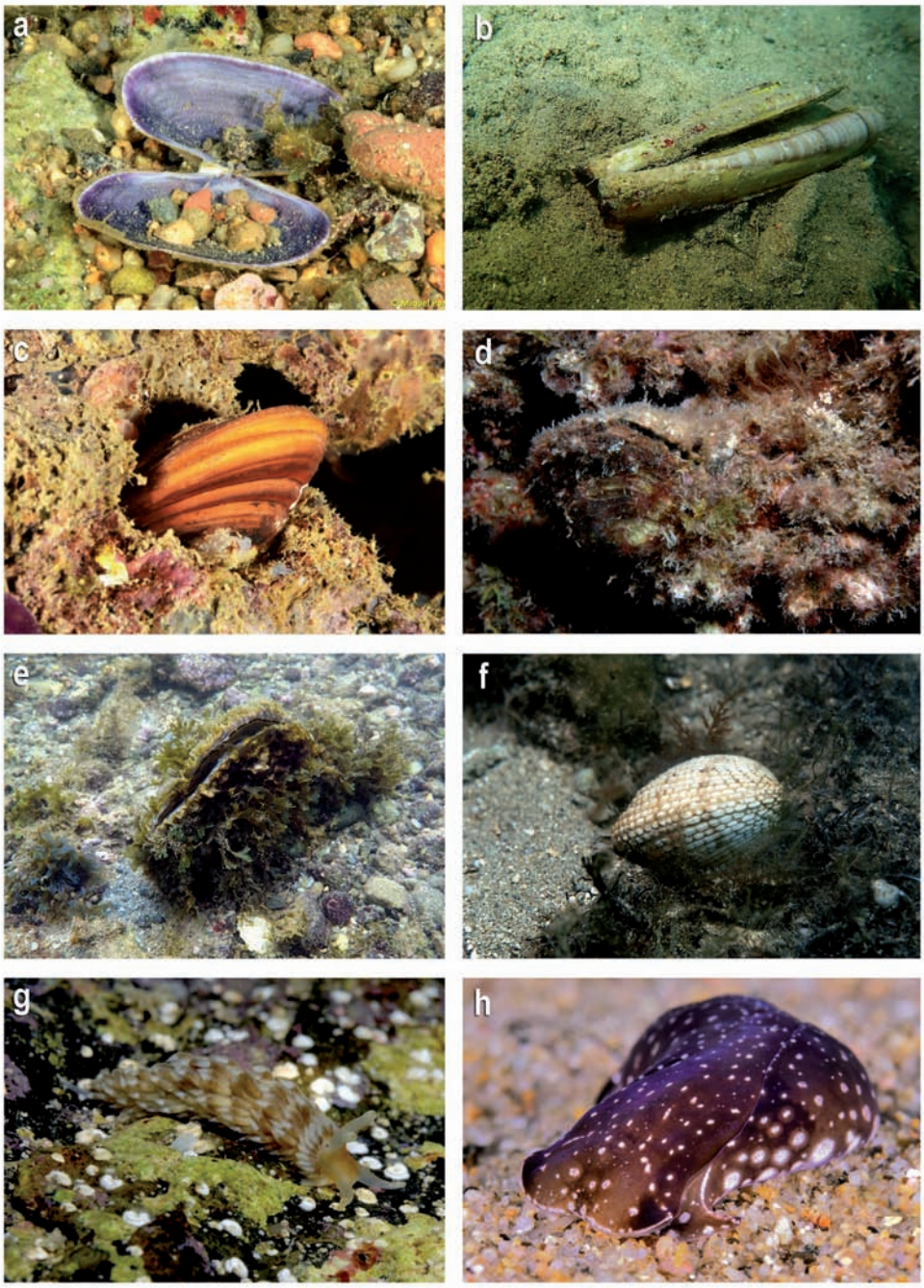

Figure 9. MOLLUSCA. a) *Donax trunculus*; b) *Ensis ensis*; c) *Lithophaga lithophaga*; d) *Ostrea edulis*; e) *Pinna nobilis*; f) *Venus verrucosa*; g) *Aeolidiella alderi*; h) *Aglaja tricolorata*. Pictures: M. Pontes (a, c, d, f, g); G. Álvarez (b, e) X. Salvador (h).

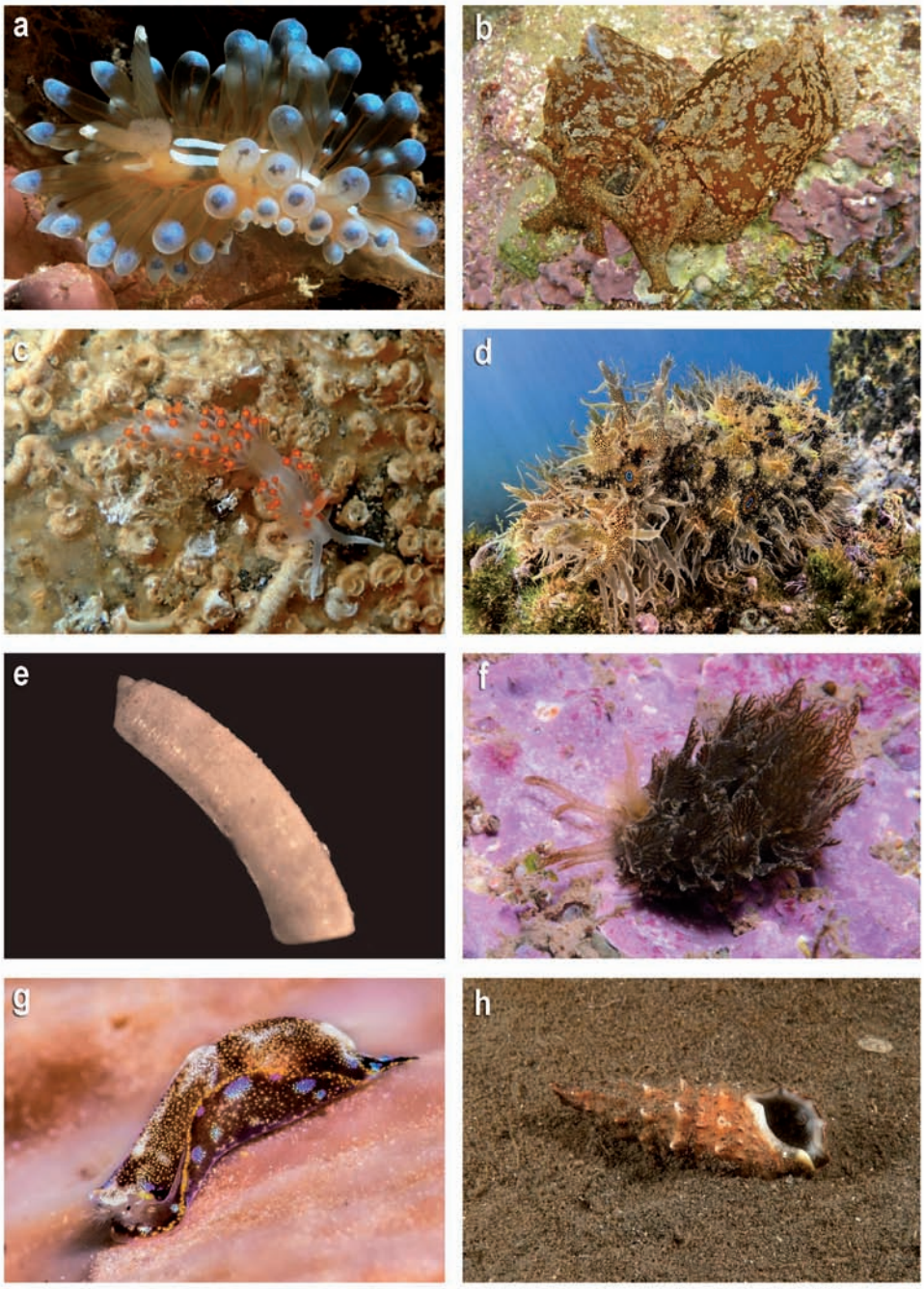

Figure 10. MOLLUSCA. a) *Antiopella cristata*; b) *Aplysia punctata*; c) *Berghia verrucicornis*; d) *Bursatella leachii*; e) *Caecum auriculatum*; f) *Caliphylla mediterranea*; g) *Camachoaglaja africana*; h) *Cerithium vulgatum*. Pictures: M. Pontes (a, h); M. Ballesteros (b, c); X. Salvador (d, f, g); G. Álvarez (e).

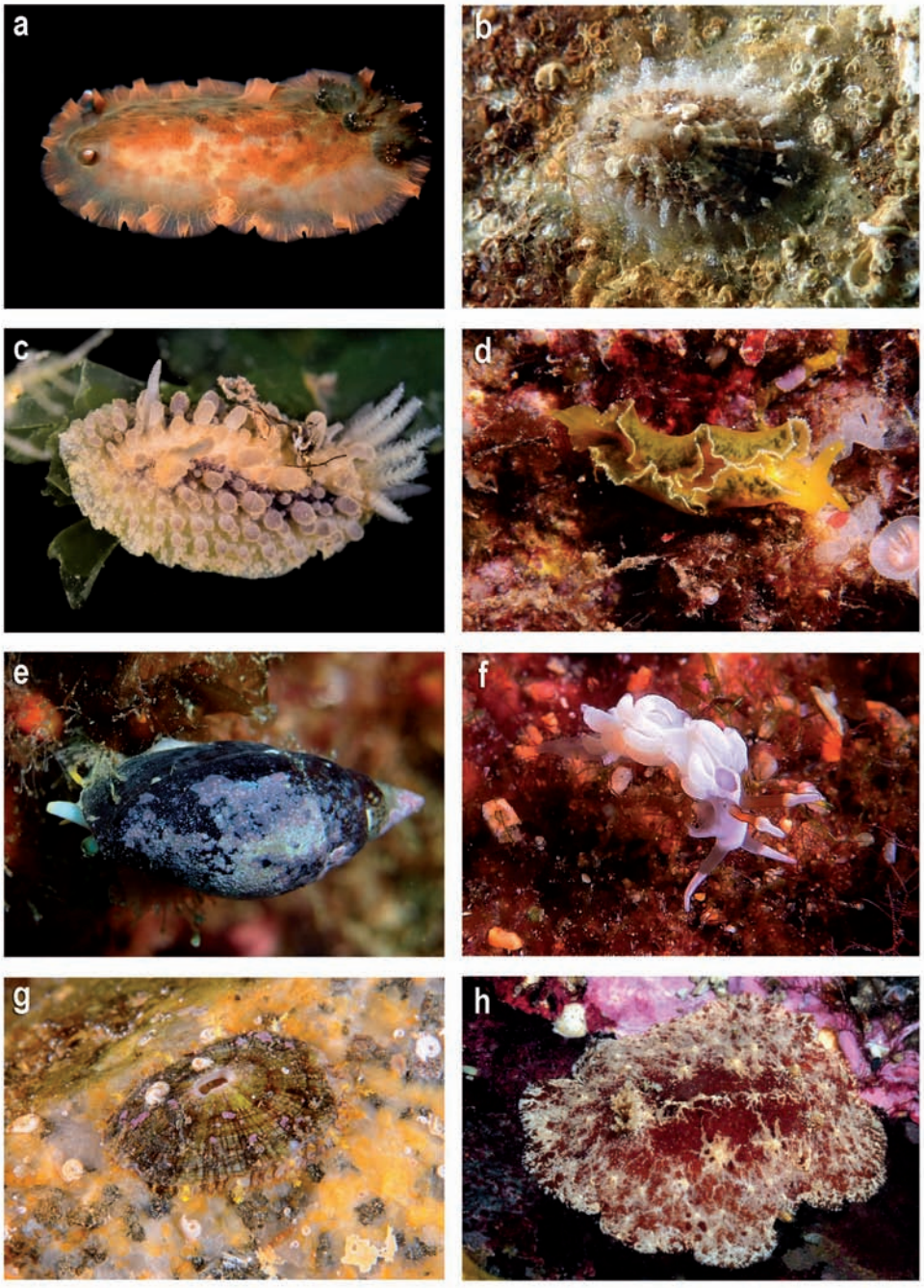

Figure 11. MOLLUSCA. a) *Dendrodoris* sp.; b) *Diodora graeca*; c) *Doris verrucosa*; d) *Elysia flava*; e) *Episcomitra cornicula*; f) *Favorinus branchialis*; g) *Fisurella nubecula*; h) *Geitodoris planata*. Pictures: M. Ballesteros (a); G. Álvarez (b); X. Salvador (c, d, e, f, g); M. Pontes (h).

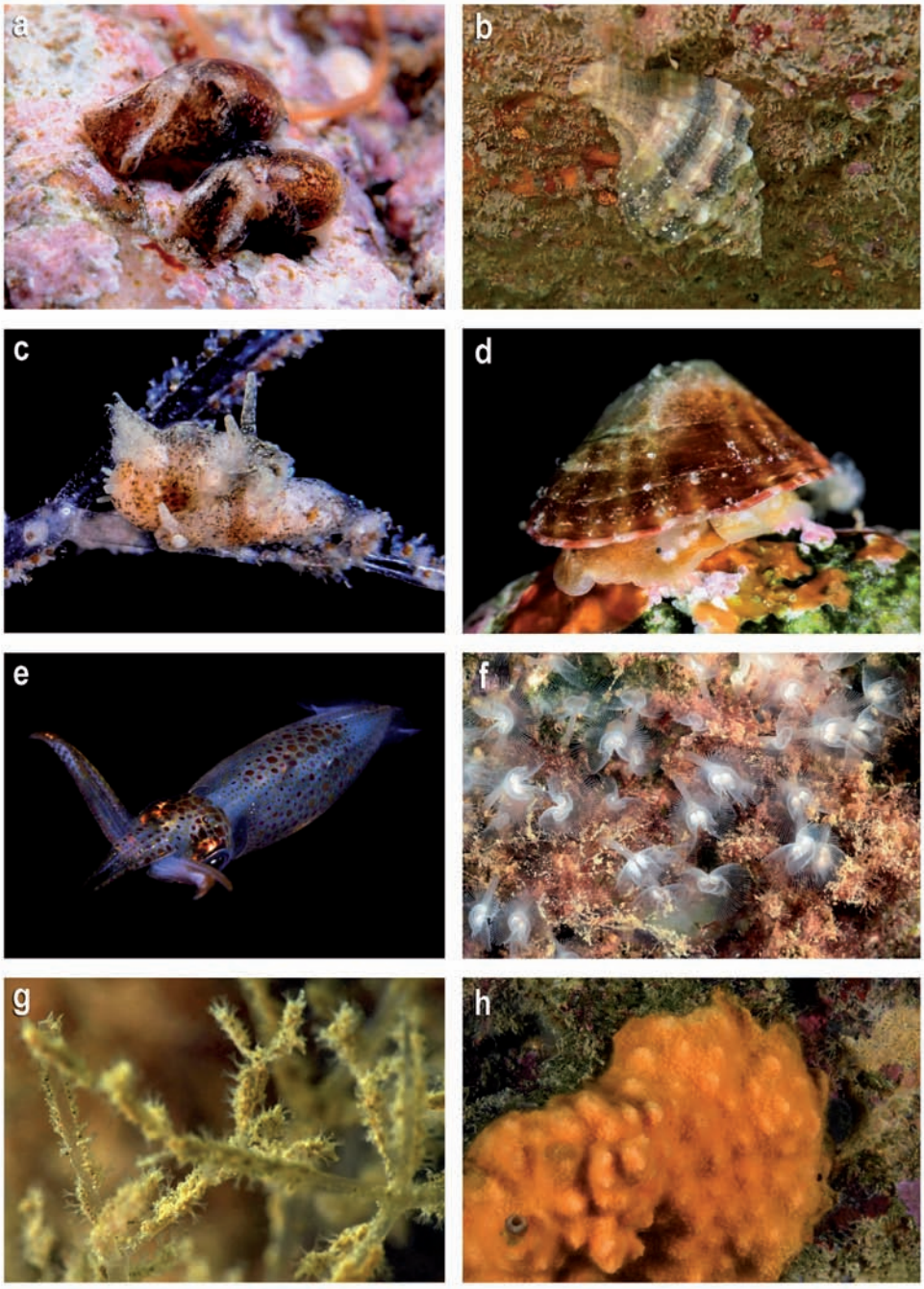

Figure 12. MOLLUSCA. a) *Haminoea hydatis*; b) *Hexaplex trunculus*; c) *Polycerella emertoni*; d) *Williamia gussoni*; e) *Loligo vulgaris*; PHORONIDA. f) *Phoronis hippocrepia*; BRYOZOA. g) *Amathia verticillata*; h) *Schizomavella (Schizomavella) mamillata*. Pictures: X. Salvador (a, c, d, e); M. Ballesteros (b); M. Pontes (f, g, h).

Phoronida (Fig. 12f)

This particular group is formed by approximately 20 species worldwide. In the Forum bathing area we observed a single species (Table 8), the horseshoe worm *Phoronis hippocrepia*. This is a tiny gregarious phoronid that usually lives on rock substrate with a certain sediment load and moderate hydrodynamism.

Bryozoa (Fig. 12g-h)

Nine bryozoan species were observed in the Forum bathing area (Table 8), six of them with encrusting growth and three species with bushy growth. Especially remarkable was the spaghetti bryozoan *Amathia verticillata,* which exhibits rapid growth in summer months, covering large, shallow, exposed areas of the walls, rocks and pylons, impoverishing the local biodiversity.

Table 8. Phoronida and Bryozoa species and observations (dd/mm/yyyy).

Phoronida species (1)	**Observations**
Phoronis hippocrepia Wright, 1856	MB (18/07/2019); MP (15/09/2018; 22/12/2018; 11/05/2019; 13/07/2019; 10/08/2019; 11/07/2020); XS (03/02/2018; 27/04/2018).
Bryozoa species (9)	**Observations**
Amathia verticillata (delle Chiaje, 1822)	MB (05/07/2018; 18/07/2019); AP (13/07/2019; 10/08/2019; 21/08/2018); MP (13/07/2019; 10/08/2019; 11/07/2020); XS (23/11/2017; 25/11/2017; 06/08/2020).
Bugula neritina (Linnaeus, 1758)	XS (27/04/2018).
Reptadeonella violacea (Johnston, 1847)	XS (27/04/2018).
Schizobrachiella sanguinea (Norman, 1868)	AP (10/04/2019; 15/06/2019; 20/09/2018); XS (27/04/2018).
Schizomavella (*Schizomavella*) *mamillata* (Hincks, 1880)	MP (15/06/2019); XS (27/04/2018).
Schizoporella errata (Waters, 1878)	XS (27/04/2018).
Tricellaria sp. Fleming, 1828	XS (27/04/2018).
Turbicellepora magnicostata (Barroso, 1919)	AP (13/07/2019; 24/07/2019); MP (11/05/2019).
Watersipora cucullata (Busk, 1854)	XS (25/11/2017; 27/04/2018).

Arthropoda (Figs 13a-h; 14a-b)

A total of 65 species were observed in our samplings. Of these, 40 species were Decapoda, 9 Amphipoda, 6 Isopoda, 5 Cirripedia, 1 Tanaidacea, 1 Mysida, 1 Copepoda and 2 Pycnogonida (Table 9). Within Decapoda, crabs (Brachiura) are very well represented, with 18 species, most of them frequent on rocky or sandy shores of the Western Mediterranean. It is worth mentioning *Atelecyclus undecimdentatus*, more abundant in the Atlantic than in the Mediterranean, as well as *Nepinnotheres pinnotheres* and *Pinnotheres pisum,* two species that live as commensals inside the pallial cavities of bivalves, and *Herbstia condyliata*, a rare species that lives under rocks. Of the Pleocyemata, *Upogebia pusilla* was only found once alive in this study, but given the amount of discarded exoskeletons found (after moulting) it is very common in the study area, as suggested by Fusté (1987). It is also worth noting the observation of a 20-cm-long specimen of *Penaeus kerathu-*

Figure 13. ARTHROPODA. a) *Atelecyclus undecimdentatus*; b) *Herbstia condyliata*; c) *Nepinnotheres pinnotheres*; d) *Penaeus kerathurus*; e) *Pinnotheres pisum*; f) *Upogebia pusilla*; g) *Paranthura japonica*; h) *Amphibalanus amphitrite*. Pictures: X. Salvador (a, d, e, f); G. Álvarez (b); À. Parera (c, g, h).

rus (Dendrobranchiata), a shrimp of nocturnal habits and of great commercial value. We identified the Isopoda species *Paranthura japonica*, appearing in both the scraping samples from walls and pylons. This species is non-native to the Mediterranean Sea (Lavesque *et al*., 2013), as is the alloctonous Cirripedia *Amphibalanus amphitrite* (see Ávila *et al*., 2018) also observed several times in our study. Copepoda specimens of the genus *Splanchnotrophus* were found as exposed egg masses on the dorsum of the nudibranch *Spurilla neapolitana*.

Table 9. Arthropoda species, observers and dates (dd/mm/yyyy).

Decapoda species (40)	**Observations**
Acanthonyx lunulatus (Risso, 1816)	AP (22/12/2018; 13/05/2019); XS (27/04/2018; 19/11/2020).
Alpheus dentipes Guérin, 1832	AP (24/11/2018; 27/02/2019; 02/04/2019; 13/05/2019; 24/07/2019).
Alpheus macrocheles (Hailstone, 1835)	GA (26/01/2019); XS (23/02/2016).
Atelecyclus undecimdentatus (Herbst, 1783)	XS (05/12/2017; 03/02/2018).
Athanas nitescens (Leach, 1814 [in Leach, 1813-1815])	XS (18/05/2018).
Calcinus tubularis (Linnaeus, 1767)	CE (13/07/2019); AP (21/08/2018;20/09/2018; 22/12/2018; 18/07/2019); MP (15/09/2018; 22/12/2018; 06/04/2019; 11/05/2019; 15/06/2019; 28/09/2019; 11/07/2020); XS (27/04/2018); MT (06/04/2019).
Carcinus maenas (Linnaeus, 1758)	XS (02/02/2019).
Clibanarius erythropus (Latreille, 1818)	MB (17/05/2018; 02/04/2019; 18/07/2019); CE (11/05/2019); AF (09/02/2019); AP (21/08/2018; 22/12/2018; 27/02/2019; 02/04/2019; 10/04/2019; 11/05/2019; 13/05/2019; 18/07/2019; 10/08/2019); MP (24/11/2018; 22/12/2018; 26/01/2019; 09/02/2019; 11/05/2019; 13/07/2019; 10/08/2019; 11/07/2020); XS (27/04/2018; 02/02/2019); MT (02/03/2019).
Crangon crangon (Linnaeus, 1758)	XS (27/04/2018).
Diogenes pugilator (P. Roux, 1829)	MP (11/05/2019; 13/07/2019).
Eriphia verrucosa (Forskål, 1775)	AP (22/12/2018); MP (26/01/2019); XS (27/04/2018); MT (02/03/2019).
Eualus occultus (Lebour, 1936)	XS (05/12/2017; 03/02/2018; 27/04/2018).
Galathea bolivari Zariquiey Álvarez, 1950	XS (27/04/2018).
Gnathophyllum elegans (Risso, 1816)	CG (09/02/2019); XS (20/11/2019).
Herbstia condyliata (J.C. Fabricius, 1787)	GA (10/12/2020).
Inachus phalangium (J.C. Fabricius, 1775)	MP (28/09/2019).
Liocarcinus corrugatus (Pennant, 1777)	XS (03/02/2018).
Lysmata seticaudata (Risso, 1816)	AP (24/07/2019); XS (27/04/2018).
Macropodia longirostris (Fabricius, 1775)	MT (06/04/2019).
Maja crispata Risso, 1827 in [Risso, 1826-1827]	CE (24/11/2018); AP (13/05/2019; 24/07/2019); MP (02/03/2019; 11/05/2019); XS (27/04/2018).
Nepinnotheres pinnotheres (Linnaeus, 1758)	AP (24/11/2018; 27/02/2019; 13/05/2019).
Pachygrapsus marmoratus (J.C. Fabricius, 1787)	AP (21/08/2018); MP (11/05/2019; 13/07/2019); XS (27/04/2018).

Pagurus anachoretus Risso, 1827 in [Risso, 1826-1827]	AP (21/08/2018; 13/07/2019); MP (02/03/2019; 11/05/2019); XS (27/04/2018).
Palaemon elegans Rathke, 1836	GA (25/12/2018); CE (11/05/2019; 13/07/2019); AF (09/02/2019); AP (22/12/2018; 26/01/2019; 11/05/2019; 10/08/2019); MP (09/02/2019; 11/05/2019; 13/07/2019; 10/08/2019; 11/07/2020); XS (27/04/2018); MT (02/03/2019; 06/04/2019).
Palaemon serratus (Pennant, 1777)	AP (24/07/2019); XS (27/04/2018).
Penaeus kerathurus (Forskål, 1775)	AP (11/05/2019).
Periclimenes amethysteus (Risso, 1827 in [Risso, 1826-1827])	GA (02/03/2019).
Pilumnus hirtellus (Linnaeus, 1761)	AP (10/04/2019; 13/05/2019; 10/08/2019); XS (02/02/2019).
Pilumnus villosissimus (Rafinesque, 1814)	XS (20/11/2019).
Pinnotheres pisum (Linnaeus, 1767)	XS (16/09/2020).
Pisidia bluteli (Risso, 1816)	XS (27/04/2018).
Pisidia longicornis (Linnaeus, 1767)	AP (26/01/2019; 10/04/2019); XS (27/04/2018).
Porcellana platycheles (Pennant, 1777)	GA (27/12/2020); AP (13/05/2019); XS (20/11/2019; 16/09/2020).
Processa cf. *robusta* Nouvel & Holthuis, 1957	GA (10/12/2020).
Processa sp. Leach, 1815 [in Leach, 1815-1875]	XS (27/04/2018).
Scyllarus arctus (Linnaeus, 1758)	XS (27/04/2018).
Sicyonia carinata (Brünnich, 1768)	XS (27/04/2018; 06/08/2020).
Upogebia pusilla (Petagna, 1792)	XS (27/04/2018).
Xantho pilipes A. Milne-Edwards, 1867	GA (28/02/2019); XS (27/04/2018).
Xantho poressa (Olivi, 1792)	GA (27/12/2020); AP (06/04/2019; 10/04/2019); MP (15/06/2019; 10/08/2019); XS (27/04/2018); MT (02/03/2019).

Amphipoda species (9)	**Observations**
Caprella acanthifera Leach, 1814	AP (24/11/2018; 27/02/2019; 13/05/2019; 10/08/2019).
Caprella sp. Lamarck, 1801	XS (27/04/2018; 16/09/2020).
Gammarus sp. Fabricius, 1775	AP (24/11/2018; 27/02/2019; 13/05/2019; 10/08/2019).
Jassa marmorata Holmes, 1905	XS (27/04/2018).
Leucothoe richiardii Lesson, 1865	XS (27/04/2018).
Orchestia gammarellus (Pallas, 1766)	AP (24/11/2018; 22/12/2018; 27/02/2019; 10/08/2019).
Phtisica marina Slabber, 1769	AP (24/11/2018; 27/02/2019).
Podocerus variegatus Leach, 1814	AP (13/05/2019).
Talitrus saltator (Montagu, 1808)	XS (27/04/2018).

Isopoda species (6)	**Observations**
Anilocra physodes (Linnaeus, 1758)	MP (28/09/2019); XS (19/11/2020).
Bopyrus squillarum Latreille, 1802	XS (06/08/2020).
Cymodoce truncata Leach, 1814	AP (24/11/2018; 22/12/2018; 27/02/2019; 13/05/2019; 10/08/2019).
Paranthura japonica Richardson, 1909	AP (24/11/2018; 27/02/2019; 10/08/2019).
Paranthura sp. Bate & Westwood, 1866	XS (27/04/2018).
Sphaeromatidae Latreille, 1825	XS (27/04/2018).

Cirripedia species (5)	**Observations**
Amphibalanus amphitrite (Darwin, 1854)	AP (26/01/2019); MP (22/12/2018; 11/07/2020).
Balanus trigonus Darwin, 1854	XS (16/09/2020).
Chthamalus montagui Southward, 1976	AP (22/12/2018).
Chthamalus sp. Ranzani, 1817	XS (23/11/2017; 27/04/2018; 20/11/2019).
Perforatus perforatus (Bruguière, 1789)	AP (11/05/2019; 13/05/2019); MP (22/12/2018); XS (20/11/2019).
Tanaidacea species (1)	**Observations**
Pseudoparatanais batei (Sars, 1882)	AP (13/05/2019).
Mysida species (1)	**Observations**
Leptomysis mediterranea G.O. Sars, 1877	AF (09/02/2019); AP (21/08/2018; 10/04/2019; 18/07/2019); MP (15/09/2018).
Copepoda species (1)	**Observations**
Splanchnotrophus sp. Hancock & Norman, 1863	XS (27/04/2018).
Pycnogonida species (2)	**Observations**
Anoplodactylus pygmaeus (Hodge, 1864)	AP (27/02/2019; 13/07/2019); XS (27/04/2018; 18/05/2018; 16/09/2020; 19/11/2020).
Pycnogonida Latreille, 1810	MB (02/04/2019; 18/07/2019); MP (28/09/2019).

Echinodermata (Fig. 14c-e)

A total of 14 species were observed (Table 10), including three species of Ophiuroidea, three species of Asteroidea, six species of Holothuroidea and two species of Echinoidea, all of them frequent and well known in the shallow bottoms of the Mediterranean. Their presence in a space as small as the Forum bathing area, where most large species of the western Mediterranean holothurians abound, might indicate the richness in organic material suspended in water.

Tunicata (Figs 14f-h; 15a)

A total of 18 species of tunicates were observed in the samplings (Table 11), including 11 species of individual growth and 7 species of colonial type. Similar to sponges, this group presents a great plasticity of colourations and shapes, and thus it is very difficult to determine the species based on underwater photography only. For this reason, we were not able to completely identify certain species. Surely the abundance of species is higher than reported, but it would be necessary to genetically sequence the specimens to properly characterise them. Particularly remarkable is the solitary ascidian *Phallusia mamillata*, a species rather typical of coastal detrital bottoms, relatively abundant in the study area, growing on all types of vertical hard structures. Numerous colonies of *Botryllus* and *Botrylloides* of different colours were observed throughout the year on all types of hard surfaces in the Forum bathing area. Until recently, *Botryllus schlosseri* and *Botrylloides leachii* were considered to have great chromatic variability, but it is proven that these species actually represent complexes of similar species, some of which, like the yellow morph of *Botrylloides*, could even be non-indigenous species (NIS).

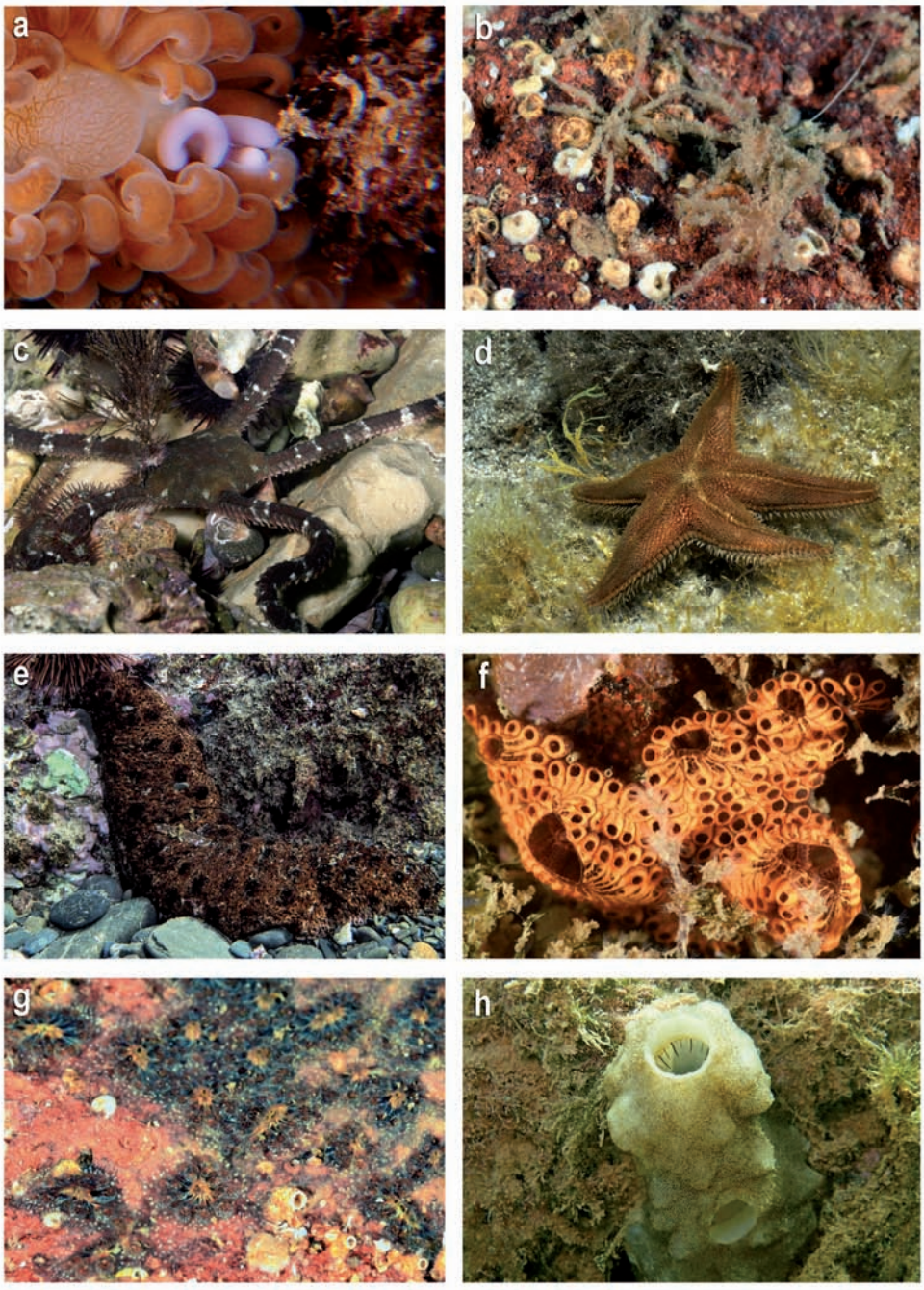

Figure 14. ARTHROPODA. a) *Splanchnotrophus* sp.; b) Pycnogonida; ECHINODERMATA. c) *Ophioderma longicauda*; d) *Astropecten spinulosus*; e) *Holothuria (Holothuria) mammata*; TUNICATA. f) *Botrylloides* sp.; g) *Botryllus schlosseri*; h) *Phallusia mamillata*. Pictures: X. Salvador (a, e); M. Pontes (b, c, d, f, g); M. Ballesteros (h).

Table 10. Echinodermata species and observations (dd/mm/yyyy).

Ophiuroidea species (3)	**Observations**
Amphipholis squamata (Delle Chiaje, 1828)	AP (24/11/2018; 27/02/2019; 02/04/2019; 13/05/2019; 10/08/2019); XS (20/11/2019; 16/09/2020).
Ophioderma longicaudum (Bruzelius, 1805)	GA (04/02/2021); XS (20/11/2019).
Ophiothrix fragilis (Abildgaard in O.F. Müller, 1789)	GA (11/05/2019); MB (18/07/2019); CE (11/05/2019); AP (24/11/2018; 27/02/2019; 10/04/2019; 11/05/2019; 13/07/2019); MP (15/06/2019; 28/09/2019); XS (16/09/2020); MT (09/02/2019; 02/03/2019).
Asteroidea species (3)	**Observations**
Astropecten platyacanthus (Philippi, 1837)	XS (06/08/2020).
Astropecten spinulosus (Philippi, 1837)	MP (28/09/2019).
Echinaster (*Echinaster*) *sepositus* (Retzius, 1783)	MP (15/09/2018).
Holothuroidea species (6)	**Observations**
Holothuria (*Holothuria*) *mammata* Grube, 1840	GA (06/04/2019; 04/02/2021); MB (05/07/2018; 18/07/2019); CE (24/11/2018); SF (26/01/2019); AP (11/05/2019); XS (27/04/2018); MT (02/03/2019).
Holothuria (*Holothuria*) *tubulosa* Gmelin, 1791	GA (11/04/2019; 04/11/2020); MB (21/09/2018; 25/10/2018; 18/07/2019); CE (24/11/2018); SF (26/01/2019); AP (12/07/2018; 21/08/2018; 20/09/2018; 22/12/2018; 26/01/2019; 10/04/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 26/01/2019; 09/02/2019; 02/03/2019; 06/04/2019; 11/05/2019; 13/07/2019; 10/08/2019; 11/07/2020); XS (27/04/2018; 19/11/2020); MT (09/02/2019; 02/03/2019).
Holothuria (*Panningothuria*) *forskali* Delle Chiaje, 1823	AP (10/04/2019; 11/05/2019).
Holothuria (*Platyperona*) *sanctori* Delle Chiaje, 1823	GA (16/01/2021); AP (24/07/2019); XS (06/08/2020).
Holothuria (*Roweothuria*) *poli* Delle Chiaje, 1824	XS (27/04/2018).
Ocnus planci (Brandt, 1835)	XS (27/04/2018).
Echinoidea species (2)	**Observations**
Arbacia lixula (Linnaeus, 1758)	GA (11/05/2019; 30/11/2019; 15/11/2020; 27/12/2020); MB (25/10/2018); CE (11/05/2019); AP (24/10/2018; 22/12/2018; 11/05/2019; 13/07/2019); MP (24/11/2018; 13/07/2019; 22/12/2018; 11/07/2020); XS (05/12/2017; 23/12/2017; 03/02/2018; 27/04/2018; 20/11/2019; 19/11/2020).
Paracentrotus lividus (Lamarck, 1816)	GA (30/11/2019; 27/04/2020; 04/11/2020); MB (17/05/2018; 05/07/2018; 21/09/2018; 25/10/2018; 02/04/2019; 18/07/2019); CE

	(24/11/2018; 11/05/2019; 28/09/2019); AF (09/02/2019); SF (26/01/2019); AP (21/08/2018; 20/09/2018; 24/10/2018; 22/12/2018; 26/01/2019; 06/04/2019; 10/04/2019; 11/05/2019; 13/05/2019; 15/06/2019; 13/07/2019; 18/07/2019; 24/07/2019; 10/08/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 26/01/2019; 02/03/2019; 06/04/2019; 11/05/2019; 13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (05/12/2017; 23/12/2017; 27/04/2018; 03/02/2018; 20/11/2019; 19/11/2020); MT (09/02/2019; 02/03/2019).

Table 11. Tunicata species and observations (dd/mm/yyyy).

Tunicata species (18)	**Observations**
Ascidia mentula Müller, 1776	GA (27/12/2020); AP (02/04/2019; 10/04/2019; 13/05/2019; 20/09/2018); MP (22/12/2018; 26/01/2019; 09/02/2019; 06/04/2019; 13/07/2019); XS (27/04/2018; 06/08/2020).
Ascidia virginea Müller, 1776	MP (09/02/2019).
Botrylloides sp. Milne Edwards, 1841	GA (04/11/2020); MB (21/09/2018; 25/10/2018; 18/07/2019); CE (13/07/2019); AP (21/08/2018; 20/09/2018; 13/05/2019; 13/07/2019; 24/07/2019; 10/08/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 11/05/2019; 13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (25/11/2017; 18/05/2018; 20/11/2019; 16/09/2020; 19/11/2020).
Botryllus schlosseri (Pallas, 1766)	MB (05/07/2018; 02/04/2019; 18/07/2019); CE (11/05/2019); AP (06/04/2019; 10/04/2019; 13/05/2019; 13/07/2019; 18/07/2019); MP (02/03/2019; 11/05/2019; 15/06/2019; 13/07/2019; 28/09/2019; 11/07/2020); XS (25/11/2017; 03/02/2018; 27/04/2018; 18/05/2018; 02/02/2019; 20/11/2019; 16/09/2020; 19/11/2020).
Ciona robusta Hoshino & Tokioka, 1967	XS (16/09/2020).
Clavelina lepadiformis (Müller, 1776)	AP (11/05/2019); XS (27/04/2018).
Didemnidae Giard, 1872	CE (13/07/2019); AP (20/09/2018; 06/04/2019; 10/04/2019; 11/05/2019; 13/05/2019); MP (22/12/2018; 09/02/2019; 06/04/2019; 11/05/2019; 28/09/2019; 11/07/2020); XS (03/02/2018; 27/04/2018); MT (06/04/2019).
Diplosoma cf. *listerianum* (Milne Edwards, 1841)	XS (27/04/2018).
Diplosoma cf. *spongiforme* (Giard, 1872)	GA (13/10/2018; 22/12/2020); MB (21/09/2018); SF (26/01/2019); AP (20/09/2018; 22/12/2018; 26/01/2019; 02/04/2019; 10/04/2019; 13/05/2019; 15/06/2019; 13/07/2019); MP (22/12/2018; 09/02/2019; 15/06/2019; 10/08/2019; 28/09/2019); XS (27/04/2018).
Lissoclinum cf. *weigelei* Lafargue, 1968	XS (19/11/2020).
Lissoclinum cf. *perforatum* (Giard, 1872)	AP (20/09/2018; 22/12/2018; 26/01/2019; 10/04/2019; 11/05/2019); MP (22/12/2018); XS

	(05/12/2017; 27/04/2018; 18/05/2018; 20/11/2019); MT (09/02/2019; 02/03/2019).
Microcosmus cf. *polymorphus* Heller, 1877	AP (10/04/2019); MP (11/05/2019).
Phallusia fumigata (Grube, 1864)	GA (06/04/2019); AP (02/04/2019; 10/04/2019; 11/05/2019; 13/05/2019; 15/06/2019; 10/08/2019); MP (24/11/2018; 26/01/2019; 02/03/2019; 06/04/2019; 11/05/2019; 13/07/2019; 28/09/2019); XS (27/04/2018).
Phallusia mammillata (Cuvier, 1815)	GA (24/11/2018; 29/08/2019; 22/11/2020); MB (21/09/2018; 25/10/2018; 18/07/2019); CE (28/09/2019); AF (09/02/2019); SF (26/01/2019); AP (21/08/2018; 20/09/2018; 26/01/2019; 06/04/2019; 11/05/2019; 13/07/2019; 10/08/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 26/01/2019; 09/02/2019; 02/03/2019; 06/04/2019; 11/05/2019; 13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (05/12/2017; 03/02/2018; 27/04/2018); MT (CE (28/09/2019);).
Pyura dura (Heller, 1877)	GA (27/04/2020; 22/12/2020); MB (21/09/2018); AP (22/12/2018; 10/04/2019; 11/05/2019; 13/05/2019; 18/07/2019); MP (09/02/2019; 15/06/2019; 10/08/2019; 11/07/2020); XS (27/04/2018; 19/11/2020); MT (09/02/2019; 02/03/2019).
Pyura sp. Molina, 1782	XS (05/12/2017; 27/04/2018; 20/11/2019; 16/09/2020).
Pyuridae Hartmeyer, 1908	XS (25/11/2017; 05/12/2017).
Styela plicata (Lesueur, 1823)	XS (27/04/2018).

Fishes (Figs 15b-h; 16a-g)

We were able to identify 88 species of fishes in the study area (Table 12) classified in the following families: 2 Torpedinidae, 1 Muraenidae, 1 Ophichthidae, 1 Congridae, 1 Phycidae, 1 Ophidiidae, 2 Gobiesocidae, 2 Atherinidae, 2 Scorpaenidae, 4 Mugilidae, 1 Moronidae, 3 Serranidae, 1 Apogonidae, 1 Haemulidae, 13 Sparidae, 1 Sciaenidae, 2 Mullidae, 1 Pomacentridae, 11 Labridae, 1 Trachinidae, 3 Tripterygiidae, 13 Blenniidae, 2 Callionymidae, 12 Gobiidae, 1 Sphyraenidae, 1 Bothidae, 3 Soleidae and 1 Syngnathidae. Our qualitative underwater visual census is affected by fish abundance, body-size and behaviour, which are known factors that strongly affect fish detectability (Prato *et al*., 2017). Certain species rarely swim close to divers and flee upon detection. Consequently, their presence and/or abundance may be under-estimated. The visibility in the Forum bathing area is usually less than three meters, so benthic species, such as blennies or gobies, are well represented. In fact, exclusively benthic fish species represent 57 % of the total survey in our study.

The presence of some rare species such as the Chestnut goby (*Chromogobius quadrivittatus*) and the Zebra goby (*Zebrus zebrus*) should be noted. These species of the family Gobiidae, catalogued as Least Concern by IUCN, have nocturnal activity and normally live inside caves or under rocks. Another group with good representation in the Forum bathing area is the family Soleidae, with three species, two of Atlantic origin: the Senegalese sole (*Solea senegalensis*), observed and fished along the Catalan coast, and the Portuguese sole (*Dagetichthys lusitanicus*) originating from the African Atlantic coasts and with very few Mediterranean reports, first observed and photographed in the Mediterranean at Cala Vidre (L'Ametlla de Mar, Tarragona, Spain) (X. Salvador, pers. obs.) and confirmed by Fishbase. Also noteworthy is the observation of the two most frequent

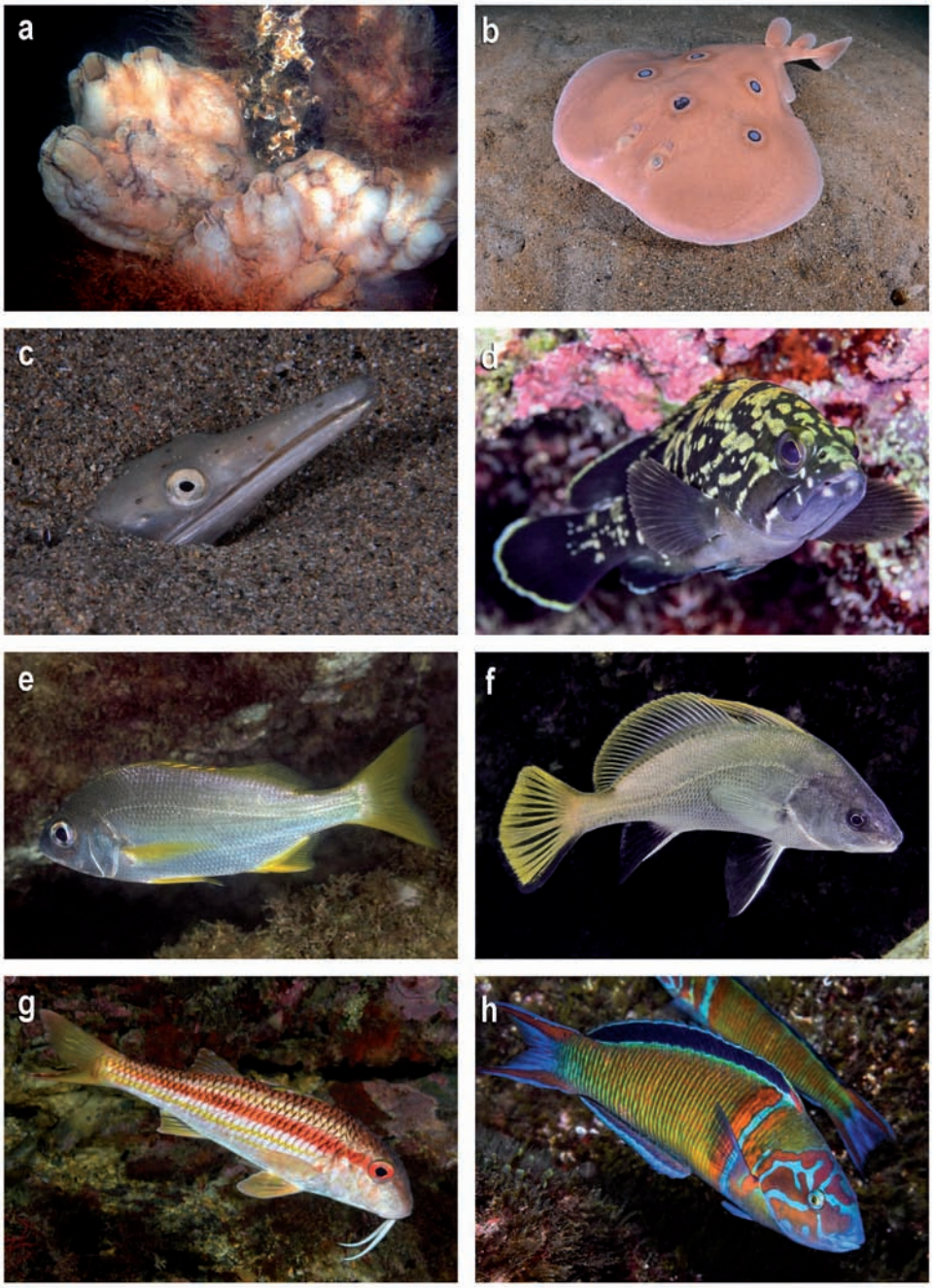

Figure 15. TUNICATA. a) *Styela plicata*; PISCES. b) *Torpedo torpedo*; c) *Ophisurus serpens*; d) *Epinephelus marginatus*; e) *Pomadasys incisus*; f) *Sciaena umbra*; g) *Mullus surmuletus*; h) *Thalassoma pavo*. Pictures: X. Salvador (a, b, c, d, f, h); M. Pontes (e, g).

Mediterranean Torpedinidae species: the common torpedo (*Torpedo torpedo*) and the marbled electric ray (*Torpedo marmorata*).

The silty bottoms located between the large rock blocks and the outer breakwater of the Forum bathing area surely provide food and shelter to some species that are typically rarely observed, as is the case of the Risso's dragonet (*Callionymus risso*), which lives in fine sand or mud bottoms and shares its habitat in the Forum bathing area with the Sailfin dragonet (*Callionymus pusillus*). *C. risso* is less abundant and is characterised by a double line of black dots on the flanks and three spines on the first dorsal fin (instead of the four in *C.pusillus*). *Ophisurus serpens* was the only large fish found in the muddy bottom, almost buried with the head visible, but very aware of its surroundings.

A curious observation was the Mediterranean sea horse (*Hippocampus guttulatus*), difficult to observe because of its extreme camouflaging abilities, with a single observation in the study zone.

It is also interesting to note the presence of *Pomadasys incisus*, a species common in the eastern Atlantic and southern coasts of the western Mediterranean, now increasingly common in the NW Mediterranean shores, perhaps due to distribution shifts of thermophile species related to climate change. This species was found forming schools with the very similar juveniles of *Diplodus annularis*.

Finally, it is worth mentioning the presence of the dusky grouper (*Epinephelus marginatus*) and the brown meagre (*Sciaena umbra*), both species of commercial interest and under high fishing pressure, classified in the Mediterranean as Endangered and Vulnerable, respectively.

Table 12. Fish species and observations (dd/mm/yyyy).

Torpedinidae species (2)	**Observations**
Torpedo marmorata Risso, 1810	XS (19/11/2020).
Torpedo torpedo (Linnaeus, 1758)	XS (23/11/2017; 25/11/2017; 19/11/2020).
Muraenidae species (1)	**Observations**
Muraena helena Linnaeus, 1758	XS (27/04/2018).
Ophichthidae species (1)	**Observations**
Ophisurus serpens (Linnaeus, 1758)	GA (05/01/2020); MP (06/04/2019); XS (27/04/2018).
Congridae species (1)	**Observations**
Conger conger (Linnaeus, 1758)	MP (28/09/2019).
Phycidae species (1)	**Observations**
Phycis phycis (Linnaeus, 1766)	XS (27/04/2018).
Ophidiidae species (1)	**Observations**
Ophidion rochei Müller, 1845	XS (27/04/2018).
Gobiesocidae species (2)	**Observations**
Lepadogaster candolii Risso, 1810	AP (10/04/2019); XS (27/04/2018).

Lepadogaster lepadogaster (Bonnaterre, 1788)	XS (19/11/2020).
Atherinidae species (2)	**Observations**
Atherina boyeri Risso, 1810	AP (24/07/2019); XS (27/04/2018).
Atherina hepsetus Linnaeus, 1758	XS (19/11/2020).
***S*corpaenidae species (2)**	**Observations**
Scorpaena notata Rafinesque, 1810	CE (13/07/2019; 28/09/2019); XS (27/04/2018).
Scorpaena porcus Linnaeus, 1758	GA (07/12/2018; 05/01/2020); SF (26/01/2019); AP (26/01/2019; 10/04/2019; 13/05/2019; 13/07/2019; 24/07/2019; 10/08/2019); MP (15/09/2018; 02/03/2019; 06/04/2019; 11/05/2019; 15/06/2019; 13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (27/04/2018); MT (02/03/2019).
Mugilidae species (4)	**Observations**
Chelon auratus (Risso, 1810)	XS (27/04/2018).
Chelon labrosus (Risso, 1827)	SF (26/01/2019); AP (21/08/2018); XS (27/04/2018).
Mugil cephalus Linnaeus, 1758	MP (10/08/2019); XS (27/04/2018).
Oedalechilus labeo (Cuvier, 1829)	XS (27/04/2018).
Moronidae species (1)	**Observations**
Dicentrarchus labrax (Linnaeus, 1758)	GA (04/11/2020); MP (11/07/2020); XS (16/09/2020).
Serranidae species (3)	**Observations**
Epinephelus marginatus (Lowe, 1834)	AP (21/08/2018; 24/07/2019); XS (27/04/2018).
Serranus cabrilla (Linnaeus, 1758)	GA (15/09/2018; 11/05/2019; 04/11/2020; 22/12/2020; 16/01/2021); SF (26/01/2019); AP (13/07/2019; 24/07/2019); MP (22/12/2018; 26/01/2019; 11/05/2019; 13/07/2019); XS (27/04/2018; 19/11/2020).
Serranus scriba (Linnaeus, 1758)	MP (28/09/2019).
Apogonidae species (1)	**Observations**
Apogon imberbis (Linnaeus, 1758)	MP (22/12/2018; 26/01/2019; 09/02/2019; 13/07/2019; 11/07/2020).
Haemulidae species (1)	**Observations**
Pomadasys incisus (Bowdich, 1825)	AP (13/07/2019; 24/07/2019; 10/08/2019); MP (13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (27/04/2018; 19/11/2020).
Sparidae species (13)	**Observations**
Boops boops (Linnaeus, 1758)	MP (22/12/2018).

Diplodus annularis (Linnaeus, 1758)	CE (28/09/2019); AP (24/07/2019); MP (10/08/2019; 11/07/2020); XS (27/04/2018; 19/11/2020).
Diplodus cervinus (Lowe, 1838)	XS (06/08/2020; 19/11/2020).
Diplodus puntazzo (Walbaum, 1792)	XS (27/04/2018; 19/11/2020).
Diplodus sargus (Linnaeus, 1758)	GA (04/11/2020); CE (11/05/2019); SF (26/01/2019); AP (21/08/2018; 20/09/2018; 24/10/2018; 10/04/2019; 24/07/2019); MP (26/01/2019; 11/05/2019; 10/08/2019; 11/07/2020); XS (27/04/2018; 19/11/2020).
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)	GA (15/09/2018; 04/11/2020; 16/01/2021); AP (13/05/2019; 13/07/2019); MP (22/12/2018; 26/01/2019; 11/07/2020); XS (27/04/2018; 19/11/2020).
Lithognathus mormyrus (Linnaeus, 1758)	XS (27/04/2018).
Oblada melanura (Linnaeus, 1758)	AP (20/09/2018; 10/04/2019; 13/05/2019; 24/07/2019); XS (27/04/2018; 19/11/2020).
Pagellus acarne (Risso, 1827)	XS (27/04/2018).
Pagellus erythrinus (Linnaeus, 1758)	XS (27/04/2018).
Pagrus pagrus (Linnaeus, 1758)	MP (15/06/2019).
Sarpa salpa (Linnaeus, 1758)	GA (05/01/2020; 22/11/2020; 16/01/2021); SF (26/01/2019); AP (21/08/2018; 20/09/2018; 24/10/2018; 22/12/2018; 10/04/2019; 11/05/2019; 13/05/2019; 13/07/2019; 18/07/2019; 10/08/2019); MP (15/09/2018; 22/12/2018; 11/05/2019; 13/07/2019; 10/08/2019; 28/09/2019); XS (27/04/2018; 19/11/2020).
Sparus aurata Linnaeus, 1758	GA (04/11/2020); AP (13/05/2019; 13/07/2019); MP (13/07/2019); XS (27/04/2018).

Sciaenidae species (1)	**Observations**
Sciaena umbra Linnaeus, 1758	MP (11/05/2019).

Mullidae species (2)	**Observations**
Mullus barbatus Linnaeus, 1758	AP (21/08/2018; 24/10/2018; 13/05/2019; 24/07/2019); XS (06/08/2020; 19/11/2020).
Mullus surmuletus Linnaeus, 1758	GA (15/09/2018); AP (13/07/2019; 18/07/2019; 24/07/2019; 10/08/2019); MP (15/09/2018; 13/07/2019; 10/08/2019; 11/07/2020); XS (27/04/2018; 19/11/2020).

Pomacentridae species (1)	**Observations**
Chromis chromis (Linnaeus, 1758)	GA (16/01/2021); CE (11/05/2019); AP (24/10/2018; 22/12/2018; 10/04/2019; 11/05/2019; 10/08/2019); MP (22/12/2018; 09/02/2019; 11/05/2019; 28/09/2019; 11/07/2020); XS (27/04/2018; 19/11/2020).

Labridae species (11)	**Observations**
Centrolabrus melanocercus (Risso, 1810)	MP (28/09/2019).

Coris julis (Linnaeus, 1758)	GA (15/09/2018; 04/11/2020; 15/11/2020; 16/01/2021); SF (26/01/2019); AP (21/08/2018; 24/10/2018; 22/12/2018; 10/04/2019; 11/05/2019; 13/05/2019; 13/07/2019; 10/08/2019); MP (22/12/2018; 11/05/2019; 11/07/2020); XS (23/12/2017; 27/04/2018; 19/11/2020).
Labrus merula Linnaeus, 1758	GA (05/01/2020); SF (26/01/2019); AP (22/12/2018; 10/04/2019); XS (27/04/2018; 19/11/2020).
Symphodus cinereus (Bonnaterre, 1788)	GA (05/01/2020); AP (24/10/2018); XS (27/04/2018).
Symphodus mediterraneus (Linnaeus, 1758)	XS (27/04/2018).
Symphodus melops (Linnaeus, 1758)	XS (05/12/2017).
Symphodus ocellatus (Linnaeus, 1758)	MP (11/05/2019); XS (27/04/2018).
Symphodus roissali (Risso, 1810)	GA (04/11/2020); AP (21/08/2018; 20/09/2018; 24/10/2018; 22/12/2018; 26/01/2019; 10/04/2019; 10/08/2019); MP (22/12/2018; 26/01/2019; 09/02/2019; 11/05/2019; 13/07/2019; 10/08/2019; 11/07/2020); XS (27/04/2018).
Symphodus rostratus (Bloch, 1797)	MP (28/09/2019).
Symphodus tinca (Linnaeus, 1758)	GA (15/11/2020; 16/01/2021); AP (10/04/2019; 24/07/2019); MP (11/05/2019; 10/08/2019; 11/07/2020); XS (05/12/2017; 27/04/2018).
Thalassoma pavo (Linnaeus, 1758)	MP (10/08/2019); XS (27/04/2018; 19/11/2020).

Trachinidae species (1)	**Observations**
Trachinus draco Linnaeus, 1758	XS (27/04/2018).

Tripterygiidae species (3)	**Observations**
Tripterygion delaisi Cadenat & Blache, 1970	GA (11/05/2019; 16/01/2021); SF (26/01/2019); MP (24/11/2018; 22/12/2018; 09/02/2019; 06/04/2019; 11/05/2019; 15/06/2019); XS (27/04/2018).
Tripterygion melanurum Guichenot, 1850	AP (10/04/2019; 11/05/2019; 24/07/2019); MP (28/09/2019); XS (27/04/2018).
Tripterygion tripteronotum (Risso, 1810)	SF (26/01/2019); AP (22/12/2018); XS (27/04/2018).

Blenniidae species (13)	**Observations**
Aidablennius sphynx (Valenciennes, 1836)	AP (22/12/2018; 26/01/2019); MP (11/05/2019); XS (27/04/2018; 19/11/2020).
Coryphoblennius galerita (Linnaeus, 1758)	XS (27/04/2018).
Lipophrys trigloides (Valenciennes, 1836)	AP (21/08/2018; 11/05/2019); XS (27/04/2018; 19/11/2020).
Microlipophrys canevae (Vinciguerra, 1880)	XS (27/04/2018).
Microlipophrys dalmatinus (Steindachner & Kolombatovic, 1883)	AP (26/01/2019; 10/04/2019); XS (27/04/2018; 16/09/2020); MT (06/04/2019).
Parablennius gattorugine (Linnaeus, 1758)	GA (19/01/2019; 27/04/2020); AF (09/02/2019); XS (19/11/2020).
Parablennius incognitus (Bath, 1968)	CE (11/05/2019); AP (10/04/2019; 13/07/2019); MP (15/09/2018); XS (23/02/2016; 27/04/2018).

Parablennius pilicornis (Cuvier, 1829)	GA (15/09/2018; 11/05/2019); CE (11/05/2019); AF (09/02/2019); SF (26/01/2019); AP (21/08/2018; 20/09/2018; 22/12/2018; 26/01/2019; 11/05/2019; 13/07/2019; 10/08/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 09/02/2019; 11/05/2019; 15/06/2019; 13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (27/04/2018; 06/08/2020; 19/11/2020); MT (02/03/2019).
Parablennius rouxi (Cocco, 1833)	CE (11/05/2019); AP (21/08/2018; 20/09/2018); MP (24/11/2018; 10/08/2019); XS (06/08/2020).
Parablennius sanguinolentus (Pallas, 1814)	GA (27/04/2020); MP (28/09/2019; 11/07/2020); XS (27/04/2018).
Parablennius tentacularis (Brünnich, 1768)	GA (05/01/2020); AP (11/05/2019; 10/08/2019); MP (06/04/2019; 11/07/2020).
Parablennius zvonimiri (Kolombatovic, 1892)	GA (06/04/2019); AP (13/05/2019); MP (11/05/2019); XS (27/04/2018).
Salaria pavo (Risso, 1810)	XS (27/04/2018).

Callionymidae species (2)	**Observations**
Callionymus pusillus Delaroche, 1809	AP (10/04/2019); XS (20/11/2019; 19/11/2020).
Callionymus risso Lesueur, 1814	XS (19/11/2020).

Gobiidae species (12)	**Observations**
Chromogobius quadrivittatus (Steindachner, 1863)	XS (02/02/2019).
Gobius cobitis Pallas, 1814	GA (15/09/2018); AF (09/02/2019); AP (21/08/2018; 20/09/2018; 24/10/2018; 22/12/2018; 26/01/2019; 02/04/2019; 11/05/2019; 13/07/2019; 18/07/2019; 24/07/2019); MP (15/09/2018; 22/12/2018; 26/01/2019; 02/03/2019; 06/04/2019; 11/05/2019); XS (27/04/2018); MT (02/03/2019).
Gobius cruentatus Gmelin, 1789	GA (02/03/2019; 11/05/2019; 11/09/2019; 04/11/2020; 22/11/2020); MP (15/09/2018; 26/01/2019; 13/07/2019; 10/08/2019); XS (27/04/2018).
Gobius geniporus Valenciennes, 1837	GA (16/01/2021); SF (26/01/2019); AP (13/07/2019); MP (26/01/2019; 11/05/2019; 13/07/2019; 10/08/2019; 11/07/2020); XS (27/04/2018).
Gobius incognitus Kovačić & Sanda, 2016	CE (24/11/2018; 28/09/2019); AF (09/02/2019); SF (26/01/2019); AP (24/10/2018; 22/12/2018; 26/01/2019; 06/04/2019; 10/04/2019; 11/05/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 26/01/2019; 09/02/2019; 02/03/2019; 06/04/2019; 11/05/2019; 15/06/2019; 13/07/2019; 10/08/2019; 28/09/2019; 11/07/2020); XS (27/04/2018); MT (09/02/2019; 02/03/2019; 06/04/2019).
Gobius niger Linnaeus, 1758	GA (11/05/2019; 15/10/2019; 21/06/2020); CE (28/09/2019); MP (11/05/2019); XS (23/02/2016; 23/11/2017; 05/12/2017; 27/04/2018; 06/08/2020;

	19/11/2020).
Gobius paganellus Linnaeus, 1758	GA (15/10/2018; 27/04/2020); SF (26/01/2019); AP (22/12/2018; 10/04/2019; 24/07/2019); MP (24/11/2018; 06/04/2019); XS (27/04/2018).
Gobius xanthocephalus Heymer & Zander, 1992	GA (15/09/2018; 13/10/2018; 02/03/2019; 11/05/2019; 16/01/2021); CE (11/05/2019); AF (09/02/2019); SF (26/01/2019); AP (20/09/2018; 22/12/2018; 26/01/2019; 11/05/2019); MP (15/09/2018; 24/11/2018; 22/12/2018; 26/01/2019; 02/03/2019; 06/04/2019; 11/05/2019; 13/07/2019; 11/07/2020); XS (27/04/2018); MT (02/03/2019).
Pomatoschistus bathi Miller, 1982	XS (27/04/2018; 19/11/2020).
Pomatoschistus marmoratus (Risso, 1810)	XS (03/02/2018; 06/08/2020; 19/11/2020).
Pomatoschistus pictus (Malm, 1865)	XS (27/04/2018).
Zebrus zebrus (Risso, 1827)	XS (27/04/2018).
Sphyraenidae species (1)	**Observations**
Sphyraena viridensis Cuvier, 1829	MP (11/07/2020).
Bothidae species (1)	**Observations**
Bothus podas (Delaroche, 1809)	XS (25/11/2017; 19/11/2020).
Soleidae species (3)	**Observations**
Dagetichthys lusitanicus (de Brito Capello, 1868)	XS (23/11/2017; 05/12/2017).
Pegusa lascaris (Risso, 1810)	XS (06/08/2020).
Solea senegalensis Kaup, 1858	XS (06/08/2020).
Syngnathidae species (1)	**Observations**
Hippocampus guttulatus Cuvier, 1829	RG (28/04/2021).

Birds (Fig. 16h)

Three species of marine birds were observed during the samplings (Table 13): the yellow-legged gull *Larus michahellis* and the common black-headed gull *Larus ridibundus,* which were observed flying over the Forum bathing area, and the cormorant *Phalacrocorax carbo,* which was observed resting on the access stairs by the sea side. However, our samplings were focussed on the submerged areas, and so a dedicated census of sea birds in the area should be carried out. We consider these species as part of the biodiversity of the Forum ecosystem as they are involved in the trophic network.

Table 13. Bird species and observations (dd/mm/yyyy).

Aves species	**Observations**
Larus michahellis J.F. Naumann, 1840	AP (24/07/2019); MP (11/07/2020).
Larus ridibundus Linnaeus, 1766	MP (11/07/2020).
Phalacrocorax carbo (Linnaeus, 1758)	AP (27/02/2019; 10/08/2019); MP (11/07/2020).

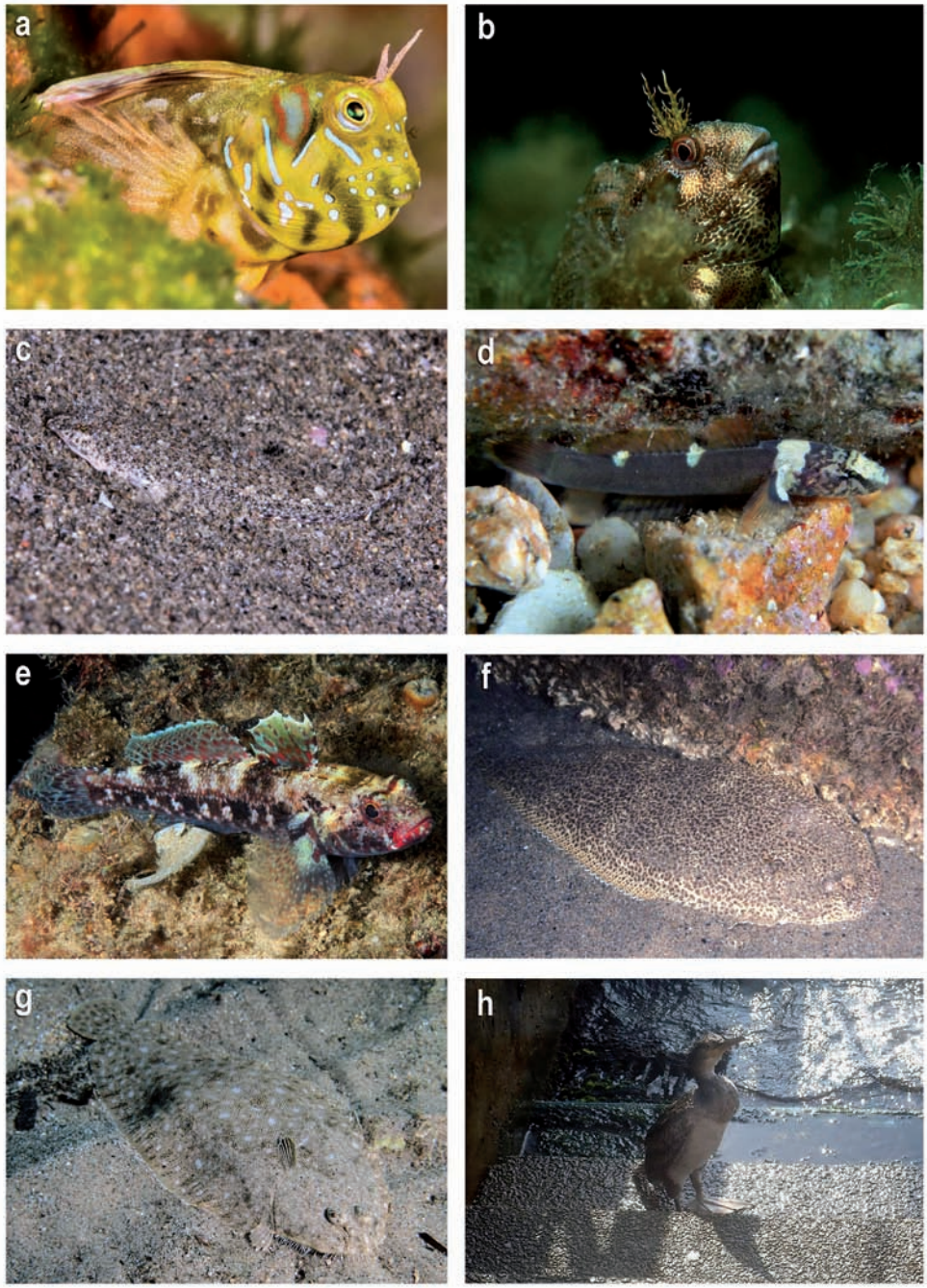

Figure 16. PISCES. a) *Aidablennius sphynx*; b) *Parablennius gattorugine*; c) *Callionymus risso*; d) *Chromogobius quadrivittatus*; e) *Gobius cruentatus*; f) *Dagetichthys lusitanicus*; g) *Solea senegalensis*; AVES. h) *Phalacrocorax carbo*. Pictures: X. Salvador (a, c, d, f, g); M. Pontes (b,e); A. Parera (h).

Discussion

General Biodiversity

It has been shown that human-made artificial substrates in the marine environment such as breakwaters, pylons and piers can be colonized by algae, invertebrates and fish, thereby altering the composition of the original biodiversity of the area (Connell, 2001).

The biodiversity results from our study in the Barcelona Forum bathing area are truly surprising in terms of the number of species registered, with more than 500 in this small area. This number will increase substantially upon the completion of the analysis of microfauna as part of a parallel quantitative study carried out by scraping concrete walls and pylons. To our knowledge, no other study carried out in marinas or commercial ports has shown such a large amount of marine biodiversity.

Elgharsalli *et al*. (2015) in their one-year study in the Hammamet Marina (Tunisia) found only 14 species of molluscs living in the sand, mud and gravel bottoms of the interior of the study area. In the present work, and even though the soft bottoms were not quantitatively sampled, molluscs were particularly well represented, with 176 identified species and, among them, 53 species of Heterobranchia, a finding published in a previous study (Parera *et al*., 2020). The studied area also seems to have ideal conditions for Cephalopoda since five different species were found: 2 Octopoda, 2 Sepiida and 1 Myopsida, with two of them (*Sepia officinalis* and *Loligo vulgaris*) found laying eggs in the area.

The nudibranch *Dendrodoris* sp. was found in several samplings and was a common finding in the shallow area at the base of the Forum bathing area stairs. *Dendrodoris* sp. is very similar to two other species of the same genus, *D. limbata* and *D. grandiflora,* and is currently being molecularly and anatomically characterised by researchers at the University of Barcelona, as it is suspected that this could be a new species or one poorly known that is cryptic with the aforementioned species.

Fishes showed an extraordinary diversity in our study area, with a total of 88 recorded species. This is especially remarkable if we take into account the small size of the study area and the limitations of the visual census due to low water visibility. Bosch *et al*. (2017), comparing the fish fauna inside and outside three marinas in the temperate eastern Atlantic, found significant differences between the two zones. It can be hypothesised that the Forum bathing area provides protection and a relatively fishing-free location for adults and juveniles to establish and mature, as in the case of the *Diplodus* species (Bouchoucha *et al*., 2016).

Another remarkable species that was found is the giant ciliate *Zoothamnium niveum*, a very particular organism that is host to the ectosymbiotic bacteria *Candidatus Thiobios zoothamnicoli*, responsible for the ciliate's brilliant white colour (Rinke *et al*., 2006) and its ability to oxidize sulphur (Bright *et al*., 2014). It lives in sulphide-rich environments from which it obtains energy thanks to the symbiont bacteria. In Spain, it has been only recorded in Lanzarote (Canary Islands) and in the Mediterranean it has been recorded in Cyprus (Eastern Mediterranean) and Giglio Island (Western Mediterranean) (Wirtz, 2008). Therefore, this is the first documented record for the Iberian Peninsula. The specimens found in our study were on a detritus area with bacterial growth, in the southern part of transect number 3, which contains high concentrations of human waste.

In the terrestrial environment, there have been studies that use nocturnal samplings to monitor certain groups, such as earthworms (Duriez *et al.*, 2006) with interesting results, showing no significant differences in other groups, such as spiders (Vedel *et al*., 2015). In the marine environment, there is a relative reduction in the density and richness of fish (Nagelkerken *et al*., 2000; Azzurro *et al*., 2007) in night samplings, although this depends on the species and its abundance. In our work, almost 100 species showed nocturnal behaviour and were observed only at night, representing about 20 % of the total. Among these were the polyplacophores (in which 100 % of species showed nocturnal behaviour and those specimens found during the day were hidden under stones), flatworms (78 % with nocturnal behaviour and some species recorded under stones), cephalopods (60 % with exclusively nocturnal behaviour), crustaceans (45 % species nocturnal, with some spe-

cies appearing in the benthos samples but openly observed in the nocturnal samplings) and the echinoderms (43 % nocturnal, with many found during the day under stones).

Alloctonous species

The total census of alloctonous species in the Forum bathing area amounts to 15 species found throughout the studied location and distributed across most of the studied groups: 2 Algae, 1 Porifera, 2 Cnidaria, 1 Annelida, 2 Mollusca, 1 Bryozoa, 3 Arthropoda and 3 Tunicata.

Algae

Asparagopsis armata Harvey, 1855 (Plantae, Rhodophyta, Florideophyceae) a seaweed originating from Australasia, now considered a cosmopolitan species, is present in all seas and oceans. An invader species in the Mediterranean, it was first reported in Algeria (Sauvageau, 1925) and is now widely distributed along the rocky coasts of Catalonia. It is found in the infralittoral zone in highly hydrodynamic and well-illuminated locations (Cormaci *et al*., 2004). Present year-round but often found as a sporophyte, it was previously thought to be a different species, *Falkenbergia rufolanosa*.

Dictyota cyanoloma Tronholm, De Clerck, Gómez-Garreta & Rull Lluch, 2010 (Chromista, Ochrophyta, Phaeophyceae) has a curious history. Initially cited in European waters as *Dictyota ciliolata* Sonder ex Kützing, 1859 (Rull *et al*., 2007), it was later described as the new species *D. cyanoloma* by Tronholm *et al*. (2010) with a type locality in the port of Palamós (Girona, Catalonia, Spain). It has been found in European waters (United Kingdom, Azores, Madeira, Canary Islands, Portugal, Morocco, Iberian Peninsula, Balearic Islands, Croatia, Greece and Turkey) and in Australia and New Zealand (Guiry & Guiry, 2021). In an attempt to explain the disjoint distribution range of this species between European waters (Northern Hemisphere) and Australian and New Zealand coasts (Southern Hemisphere) and to discover the true origin of the species, Steen *et al.* (2017) carried out a phylogenetic analysis of specimens from both geographical areas and compared their affinities to other Australian species of the genus *Dictyota*. They concluded that from a genetic point of view *D. cyanoloma* has more affinity with Australian species than with those of European waters. Also, in the Southern Hemisphere *D. cyanoloma* lives in natural rocky habitats, and in European waters it occurs in non-natural environments such as commercial ports and marinas only. For these reasons the aforementioned authors concluded that, although the type locality of the species is in the Mediterranean, it is actually a Southern Australia and New Zealand species, a conclusion supported by other authors (Aragay *et al*., 2016) as well. Therefore, in European waters it should be considered an introduced species, as we accept in this paper.

Porifera

Paraleucilla magna Klautau, Monteiro & Borojevic, 2004 (Porifera, Calcarea) is a sea sponge originating from Brazil (Klautau *et al*., 2004) and widespread across the Mediterranean Sea, where it shows a strong seasonality. It can be found in huge densities during most of the year, but almost disappears in late summer and autumn. Its spread vector is unknown, but it could be related to bivalve aquaculture, as fouling on ships' hulls or in ballast waters (Longo *et al*., 2007).

Cnidaria

Oculina patagonica de Angelis, 1908 (Cnidaria, Anthozoa, Hexacorallia) is a scleractinian coral traditionally believed to be an alloctonous species coming from Atlantic waters. However, recent works suggest that Mediterranean populations of *O. patagonica* have long been isolated from the Atlantic, either in undetectable numbers or overlooked at sampled sites and habitats, and have only recently been expanding to invasive levels as a result of environmental changes (Leydet & Hellberg, 2015). Initially recorded in the Mediterranean in 1966, it has since been reported in all the Mediterranean shores from Israel to Spain (Fine *et al*., 2001). It seems to have a complex survival strategy in the relatively cold NW Mediterranean waters, with many bleaching events, one of which we were able to observe directly.

Pennaria disticha Goldfuss, 1820 (Cnidaria, Hydrozoa) is a species of athecate hydroid in the family Pennariidae. Probably originally from the western Atlantic Ocean, it is now widely distributed in warm waters throughout the world. It is found in shallow water attached to hard surfaces, on both rocks and human-made structures, in locations with some water movement. This hydrozoan forms part of the community of organisms known as «fouling», that attach themselves to maritime structures and ships' hulls, and spreads around as a result of maritime activities (Eldredge & Smith, 2001).

Annelida

Branchiomma luctuosum (Grube, 1870) (Annelida, Sabellida), a sedentary polychaete worm originally from the tropical Indo-Pacific, demonstrates excellent survival abilities in eutrophic areas. Reported the first time in the Mediterranean at the Lucrino lagoon (Naples, Italy), it is now widespread from Turkey (Çinar *et al*., 2006) to the Spanish shores, where it has been known since 2007 in the Port of Valencia (El Haddad *et al*., 2007). As the first report was from Italy, far from the Suez Canal, it is not considered a Lessepsian species, so the first populations reported (most of them near maritime ports) were assumed to arrive in ships' ballast waters as lecithotrophic larvae. In our study, *B. luctuosum* was very abundant both in the muddy sandy bottom, under stones and even on submerged ropes with abundant sedimentary particles. It was observed in the two chromatic forms of its gill cirrus, orange and dark brown.

Mollusca

Bursatella leachii Blainville, 1817 (Mollusca, Gastropoda) is a sea hare of tropical origin that can measure up to 200 mm with a colouration and shape that makes it almost undistinguishable from the substrate. It was reported for the first time in Spain in Andalusia (Ibáñez-Yuste *et al*., 2012). Specimens found on the Spanish shores have been molecularly characterised as belonging to the Atlantic Ocean population (González & Wangüemert *et al*. 2014). In our study *B. leachii* was observed sporadically throughout the year, with generally a few specimens on each sampling day.

Polycerella emertoni A. E. Verrill, 1880 (Mollusca, Gastropoda) is a western Atlantic nudibranch species, now also found across the Mediterranean Sea. It lives on the bryozoan *Amathia verticillata,* which is considered the most likely spreading vector (Tamsouri *et al*., 2014). Traditionally reported as feeding on *A. verticillata* due to their close relationship, a recent work (Camps-Castellà *et al*., 2020) demonstrated that this nudibranch grazes on the diatoms covering the bryozoan, and is thus the first known herbivorous nudibranch.

Bryozoa

Amathia verticillata (Delle Chiaje, 1822) (Bryozoa, Gymnolaemata) is an invader bryozoan originally believed to be a Mediterranean species. First reports were from Egypt (Ehrenberg, 1828) as *Zoobotryon pellucidus* but it is now considered a pseudoindigenous species (Galil & Gevili, 2014). Its true origin is probably the Western Atlantic, as it grows naturally in the Caribbean Sea, while in the Mediterranean it mostly grows on artificial substrates and mostly in summer. The spreading vector was probably ships' hulls, as 19th century ships did not use ballast water, nor was any aquaculture performed (Marić *et al*., 2017). In our study *A. verticillata* appears as an opportunistic species that grows on the concrete walls and the breakwater rocks of the Forum bathing area during the summer months, when it also occurs in other places on the Catalan coast such as the bays of the Ebro Delta (M. Ballesteros, pers. obs.).

Arthropoda

Paranthura japonica Richardson, 1909 (Arthropoda, Isopoda), originally from the Asian Western Pacific and recorded for the first time in Europe in 2007 at Arcachon Bay on the Atlantic coast of France (Lavesque *et al*., 2013), it was first reported in the Mediterranean Sea in 2010 (Ulman *et*

al., 2017). Because of its crypticity, *P. japonica* may have been present on European coasts since before the year 2000 (Pezy *et al*., 2020). First Mediterranean records of *P. japonica* were attributed to aquaculture transfers (Marchini *et al*., 2014), but it is increasingly believed that it is approaching a well-established cosmopolitan status, and thus following its invasive trajectory has become complicated (Ulman *et al*., 2017). Reviewing all the previous bibliographic citations, we have no doubts that the specimens found in our study belong to this species. Martínez-Laiz *et al*. (2018) cite this species in different ports and marinas of the Iberian Peninsula, including the port of Barcelona.

Amphibalanus amphitrite (Darwin, 1854) (Arthropoda, Cirripedia) is a sedentary crustacean originally from the western Indo-Pacific (Marić *et al*., 2017) but actually widespread in most oceans. First Mediterranean reports were from Rijeka Bay, Croatia, in the Adriatic Sea (Zavodnik & Kovačić, 2000). It was believed its expansion vector was as fouling on ships' hulls (Carlton *et al*., 2011), but it may also be transported with oyster shipments (Grizel & Héral, 1991; Wiegemann, 2008).

Balanus trigonus Darwin, 1854 (Arthropoda, Cirripedia) is native to the Pacific and has been cited throughout the Indo-Pacific, and both shores of the Atlantic and the Mediterranean, where it has been known since 1927 (Patane, 1927, Gulf of Catania, Italy). It is postulated that this species may have been transported via aquaculture or on commercialised live shellfish, such as lobsters and crabs (Ulman *et al*., 2017).

Tunicata

Botrylloides spp. (Tunicata, Ascidiacea) colonies were frequently found in our study and are very similar to the Mediterranean species *Botrylloides leachii* (Savigny, 1816). Recently Viard *et al*. (2019), while studying a wide collection of their own molecular data and those in GenBank, have verified the existence in the bibliography of numerous misidentifications in the Mediterranean assigned to *B. leachii* when in fact they corresponded to *B. diegensis*, an introduced species native to the California coast. The golden orange *Botrylloides* colonies that appear in our study area are very similar to both *B. diegensis* and *B. niger*, the latter a circumtropical and non-native species in the Mediterranean very common in the Caribbean Sea, also detected in the British Islands and in Australian waters. If this is the case, the most likely spreading vector would be ships' hulls where it could survive as "fouling". Sampling and molecular analysis would be necessary to clarify doubts about the specific status of the *Botrylloides* colonies of the Barcelona Forum.

Microcosmus cf. *polymorphus* Heller, 1877 (Tunicata, Ascidiacea) is a solitary ascidian widespread in the Atlantic Ocean, entering the Mediterranean Sea through the Strait of Gibraltar, perhaps as fouling on ships' hulls or in ballast waters. Initially reported in the Aegean Sea (Greece) (Koukouras, 2010), it apparently spread first across the western Mediterranean Basin and is now also spreading to the eastern basin (Cihangir *et al*., 2010).

Styela plicata (Lesueur, 1823) (Tunicata, Ascidiacea) is a solitary ascidian found in protected tropical and warm-temperate waters, especially inside ports, with a global distribution attributed to commercial shipping (De Barros, 2009). Of unknown origin, its presence in the Mediterranean Sea has been confirmed since the 20th century (Harant, 1927).

Unlike the eastern and central Mediterranean basins, where the main pathway of introduction of non-indigenous species (NIS) is the Suez Canal (Galil *et al*., 2018), in the western Mediterranean Sea, as on other coasts of Europe, most NIS have been introduced by commercial shipping and aquaculture (Marić *et al*., 2017). Leisure boats are also capable of spreading NIS both on an international and local level (Minchin *et al*., 2006), and in some regions they are considered to be the most important introduction vector of such species (Clarke Murray *et al*., 2014). Moreover, the northward expansion of NIS already established on the Spanish coast due to climate change is also suspected as an important pathway for the expansion of such species.

The large number of harbours and docks in the Catalan shores (Generalitat de Catalunya, 2021) that have been built over the years (one every seven miles on average on a coastline of just over 580 km) together with the behaviour patterns of the leisure boats (Cornell, 2002) enable NIS to become

widely distributed well beyond commercial shipping ports and aquaculture zones. The structure of small harbours, protected from rough seas by extensive breakwaters, offer many settling opportunities for benthic species, enhancing the probability of NIS retention and establishment once introduced.

Thus, the presence of 15 non-indigenous species (NIS) in the Forum bathing area should not be surprising for the abovementioned reasons and because of other effects of climate change, causing a sort of "tropicalization" of the Mediterranean Sea. In a study to analyse the presence of non-indigenous species in three marinas in Tunisia and Egypt, Sghaier *et al*. (2019) found a total of 27 NIS among macrophytes, invertebrates and fish, indicating that 24 were of Indo-Pacific origin, reaching the Mediterranean Sea via Lessepsian migration. Other authors, such as Bensari *et al*. (2020), cite the presence of 10 invertebrate NIS inside the port of Arzew (Algeria). Ulman *et al*. (2017) carried out a very complete study of NIS in 34 marinas throughout the Mediterranean, finding a total of 76 species; among the marinas studied by these authors was the One Ocean Marina in Port Vell (Barcelona), very close to our study area, where the researchers found a total of 11 NIS, fewer species than in our study. Our study area is located NW of the Mediterranean, where the waters are colder and this might slow down the arrival of Lessepsian species. A work by Galil (2008) has addressed the patterns of NIS arrival and settlement in the Mediterranean.

Marine litter

The Forum bathing area has a great biodiversity, but also large amounts of anthropogenic litter. Geographically, the Forum bathing area is enclosed between the Port Forum and the Besós River mouth to the north, and the Forum wastewater treating plant outlet channel to the south (Fig. 1).

Barcelona's urban sewerage system has large collector units for evacuating both wastewater and rain water previously retained in large tanks designed to cope with heavy rain episodes, enabling a certain regulation of the water flow to avoid flooding and sewage system overflows in the lower city. However, as the collectors receive both types of water (hence the name «combined sewers»), during heavy rain episodes common in late summer and autumn, water enters the combined sewer network faster than it was designed for, overflowing urban waste water treatment plants, and thus untreated sewage flows into the city rivers and nearby coastal areas (EEA, 2021).

The most abundant litter found in the Forum bathing area are wet wipes. Wet wipes become a real problem when they begin to degrade, as the relatively compact wipe transforms into a certain quantity of chemically treated fibres that become entangled in stones and living organisms, often creating a cover that disturbs, or directly suffocates, the underlying benthic organisms, ultimately killing them. We have observed another effect that we call «wet wipe rolls»: the combination of degraded wet wipes entangled with algae and other debris, combined with constant water movement forms long moving rolls (some longer than 10 m) that mechanically disturb and destroy any small fauna living on the shallow sand flats.

Other types of litter commonly found were plastics and microplastics of many origins: plastic bags, candy wrappers, plastic cotton buds, glass and plastic bottles, plastic caps, yogurt containers, soft drink and beer cans, small plastic sheets used in shows and parties, blown up latex balloons, sanitary napkins and so on. We also found worn car tyres, chairs, umbrellas, spoons, fishing rods and the strangest finding, a gun with bullets inside a blue plastic bag found during a popular beach cleaning event on July 8th, 2018.

For the fauna and litter samplings, and given the low depth of the sampling site, we used an experimental geolocation system to create distribution maps that show the highest concentration of flora and fauna, as well as litter.

The resulting maps show that the highest concentration of fauna is in the rocky area outside the pylons, and in the very shallow water along the stairs of the shoreline. On the other hand, litter is grouped in three different zones: in the bath area on the flat concrete surface (with higher hydrodynamism) we found the wet wipe rolls; scattered points of heavier litter (glass bottles, cans); and in the outermost area (outside of the pylons) there were some ropes, entangled between large rocks, that serve as a trap for wet wipes and other litter like worn tires and textiles.

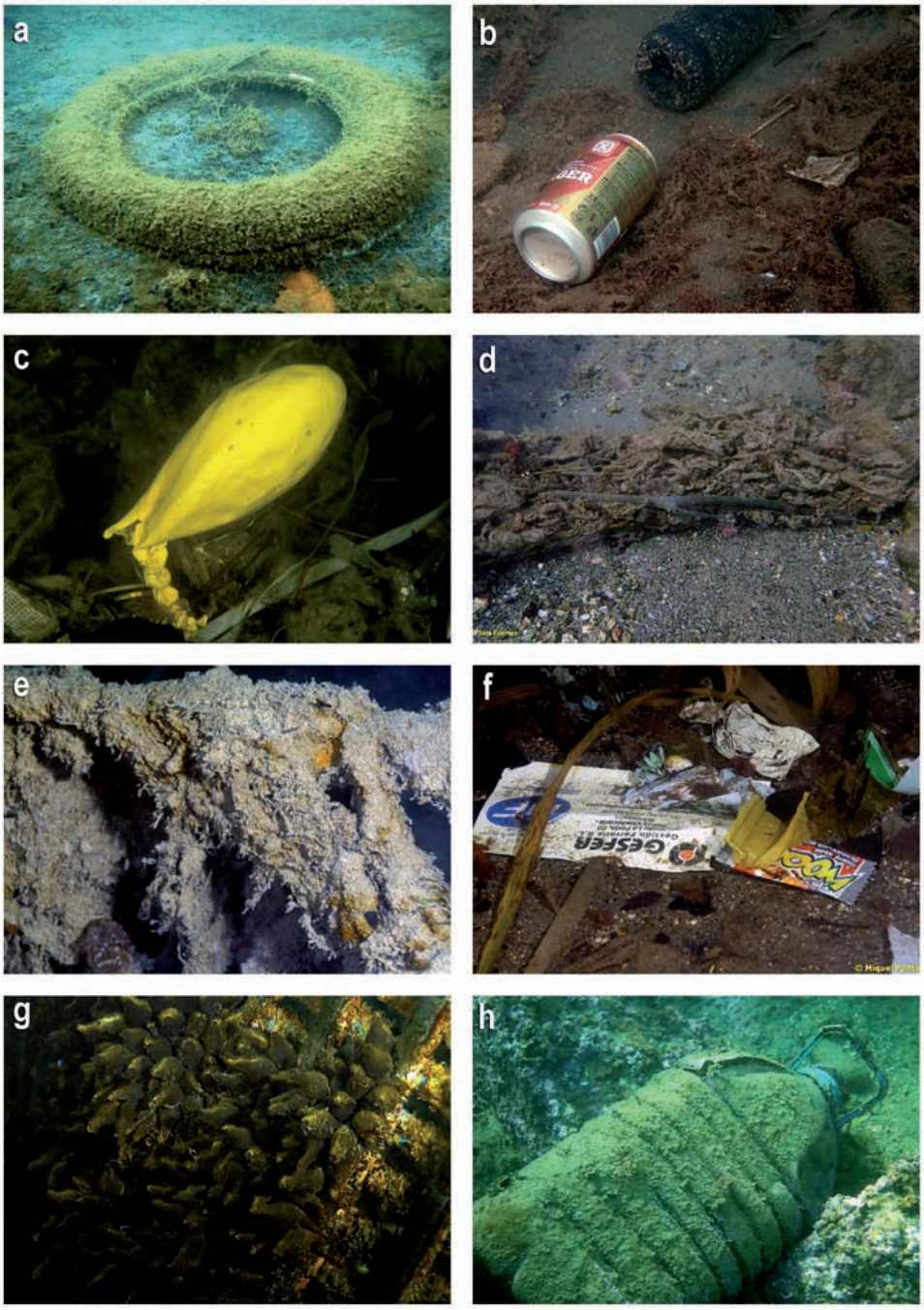

Figure 17. MARINE LITTER. a) Car tire; b) Beer can and plastic bottle; c) Discarded latex balloon; d) Wet wipes roll with algae and branches; e) Wet wipes curtain hanging from a submerged rope; f) Microplastics; g) Plastic grid filled with cuttlefish egg spawn; h) Water bottle. Pictures: M. Pontes (a, b, c, e, f, g); S. Fuertes (d); A. Parera (h).

Regarding the anthropogenic waste in the study area, which was assessed by geolocated pictures, we believe the scattered litter poses little to no risk for local fauna, as some authors have recently verified (Rizzo *et al*., 2021). However, the wet wipe rolls have a large impact on small sessile fauna, decreasing their abundance. Other areas with ample litter tend to be avoided by fauna, but the rocky area outside of the pylons shows a higher concentration of fauna cohabiting with litter because they apparently have better survival opportunities there than in the epibenthic zone or below rocks to avoid suffocation by wet wipes..

Conclusions

This study uncovered an extraordinary diversity of marine organisms living in the Barcelona Forum bathing area. With regard to fish, it is hypothesised that the study area acts as a refuge for both juvenile and adult forms, especially Labridae, Sparidae, Gobiidae and Blenniidae species, due to its stable environment and because fishing inside the bathing area is forbidden. It is also verified, as other studies indicate, that the interior of marinas such as the Forum bathing area are ideal environments for the settlement of non-indigenous species (NIS), with a total of 15 species identified in this small study area. Artificial surfaces such as concrete walls, pylons and breakwater blocks have proven to be a very suitable substrate for the growth of seaweeds (50 species) and encrusting invertebrates (54 species, of which 27 are sponges, 9 are bryozoans and 18 are tunicates). Molluscs showed the greatest specific diversity, and Heterobranchia is notable with 53 species, many of them typical of marine communities with open and clean waters. Also, the synergies established between professional scientists and citizen science volunteers demonstrate once again that this collaboration can be profitable for both communities, greatly enhancing scientific results with little to no overhead costs, and raising awareness amongst the public on scientific methods and the anthropic effects on the ecosystem. Finally, we consider that the study area, located within the city of Barcelona, easily accessible by public transport, and with Saita Diving Center and Federació Catalana d'Activitats Subaquàtiques (FECDAS) facilities on site, to be of great interest for teaching marine biodiversity to school groups and to the general public. It is important to promote marine environmental education among citizens, particularly those frequenting the bathing area, so that they understand that the most basic, and perhaps the most important, link to good environmental management is at the individual level, in our own behaviour.

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